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Forthcoming Events.

NOVEMBER 6.

British Foundrymen's Association (Lancashire Branch).—"The Moulder and Chemical Analysis, with some Notes on Contraction," by Mr. F. Andrew (Oldham).

NOTES AND COMMENTS.

The Matter of Analyses.

We are pleased to note the manner in which our readers are taking advantage of our offer to carry out their analytical work at cheap rates, for it is a good indication of the movement towards greater accuracy in foundry matters. For the assistance of those wishing to prepare samples for analysing, we append the following instructions:—

In taking a sample from an iron casting, a hole should be drilled and the first portion of the drillings rejected, the remaining drillings forming the sample for analysis, so that the sample may contain none of the outer skin. The drillings taken should be as small as possible, a three-quarter inch drill being the most convenient for the purpose, where practicable. The depth of the drill hole will of course vary with the size of the casting, but it should be about one inch deep where possible. In the case of light castings, where it is not possible to make a deep hole, it is better to drill several holes, rejecting the top drillings in each case. The minimum quantity required for each sample is about 2 ozs. The method of sampling for pig-iron is similar in principle, and has been fully described at various times in our columns. With regard to the sampling of coke, it is advisable to break off from 20 to 30 pieces of about 1 in. in size, from various lumps in the truck. For a sample of sand small quantities should be taken from various parts of the truck, so as to get as near an average sample as possible. The quantity required for a sample is from 2 to 3 lbs.

The Standardisation of Foundry Flasks.

A plan for establishing what may be called an United States standard for foundry flasks, has been submitted by Mr. M. W. Griswold, of New Jersey, U.S.A., to "The Metal Worker." At present the flasks of one foundry are not interchangeable with those of another for castings of substantially the same size. It is, perhaps, not so much the size of the flasks that is the cause of trouble as the location of the flask pins, a small fraction of an inch play making it impossible in many cases for a cope from one foundry to fit the drag from another without running the risk of castings showing too prominently the line of parting. The following is the substance of Mr. Griswold's idea, calculated to apply to flasks of all depths:—"On account of the variation of castings for flasks, all measurements as to list sizes must be made on the inside at the parting line, and the sizes listed at the full half-inch found next below the actual measurement. To illustrate: Should the actual width be 12⅝ in. and the length, say, 14 3-16th in., it must be listed as 12½ by 14. The locations of the pin holes are not to be made from the actual measurement of the flasks, but from the list size as provided for above. In locating the pin holes, the measurements must be made from lines drawn at right angle through the actual centre of the flask, and the distance apart along the sides of the flask from centre to centre of the pin holes must be exactly three-fifths of the list length (or three-tenths from the actual centre line). The distance apart, across the flask, must be exactly 2¾ in. greater than the list width, or 1⅜ in. more for the distance from centre line to centre of pin holes. The distance 1⅜ in. is taken as being practically 35 mm. For flasks of less than 500

square inches of surface measure, the pin holes must be exactly ½ in. in diameter." It is important to notice that the location of the flask pins will be identical with all flasks of the same list size, and, incidentally, it may be stated that Mr. Griswold finds that these dimensions show a very close agreement to most of the flasks now in use.

Aluminium in Brass.

A good deal of interest has at times been felt and expressed by brass founders regarding the influence of the small quantities of aluminium which sometimes occur in brass used for casting. Aluminium, while not likely to be accidentally present in brass made from good ingot metals, may be possibly present in scrap metal, or in ingots run down from scrap. In such cases it is not always welcomed by the foundryman, but in other cases again, aluminium is added to brass in quantities up to 3 or 4 per cent., in order to produce what is known as aluminium brass. This alloy, of course, is quite distinct from the aluminium bronzes—alloys of copper and aluminium, the latter up to 10 or 11 per cent. The micro-structure of the aluminium brasses is practically the same as that of ordinary brasses, the aluminium having the effect of a further addition of zinc, except that it is more powerful. As a casting metal aluminium bronze is excellent, and may be applied to a great variety of uses where a strong brass is needed.

About 4 per cent. may be taken as the limit for the aluminium content of brass, if strength requirements are of importance, or particularly if the metal has to be worked. The brasses containing from 60 to 70 per cent. of copper are those most suitable for the addition of aluminium, and as instancing the effect of varying amounts may be taken a few of the results obtained by Guillet, in the course of his experiments. With an alloy of copper 69 per cent. and zinc 29.9 per cent., as small an amount of aluminium as 0.4 per cent., gave a tensile strength of 12.6 tons per square inch, and elongation 59 per cent.; with an alloy of 70.5 per cent. copper and 26.4 per cent. zinc, the addition of 3.1 per cent. aluminium gave 21.5 tons tensile strength, 8.5 tons elastic limit, and elongation 50 per cent. These results, compared with those given by ordinary brasses of these compositions, illustrate the effect of aluminium. As illustrating the effect of larger amounts than 4 per cent. aluminium, may be quoted a test on an alloy of 70.1 per cent. copper and 24.7 per cent. zinc.; 5.2 per cent. aluminium added to this gave 32.2 tons tensile strength, 4.7 tons elastic limit, and 11 per cent. elongation, the strength being thus materially increased, but at the expense of ductility.

The aluminium-brasses are employed for a considerable variety of work, such as propellors, pumps, valves, pinions, etc., and are not particularly difficult to handle in the foundry. It is essential, however, that castings of these alloys be slowly cooled, as sudden cooling is liable to result in weak crystallisation. The fracture of suddenly-cooled metal is very different from that of the same composition slowly cooled, being deep gold in colour and with a glittering lustre.

The Electric Smelting of Iron Ore.

The possibilities of the electric smelting furnace as a producer of pig-iron have been frequently discussed of late, and now the British Legation at Christiania report that the iron produced at the experimental furnace erected at Tinnfos, near Skien, Norway, which can be manufactured at about £3 per ton, is capable of competing with the best Swedish "charcoal iron," costing from £5 to £5 10s. per ton. The production at Tinnfos is at present three tons a day; when the power at the works has been increased to 1,000 h.p., 25 tons a day will be turned out. The ore, which is smelted directly in the furnace, is said to contain 45 per cent. of iron. It is proposed to develop the works for the manufacture of steel, which it is said can be produced at from £4 to £4 10s. per ton, whereas Swedish "charcoal steel" of similar quality costs nearly £10 per ton. H.M. Legation are informed that there is a Swedish patented invention for the same purpose, which is said to give excellent results and to be more reliable, and that some furnaces are shortly to be erected near Christiansand.

Institute of Metals.

The Autumn Conference of the Institute of Metals opened in the lecture theatre of the University of Glasgow, on September 21, under the Presidency of Sir Gerard Muntz.

Sir Gerard Muntz, in opening the business proceedings, said that interesting Papers had been put forward in the hope of eliciting discussion on points of practical interest. When the Institute commenced its work, many problems were without form and void. The Institute had now achieved some good work in obtaining information in a concrete form concerning the non-ferrous metals. Those engaged in the industry realised that there was a great deal yet to learn and extreme diversity of opinion still existed among all classes interested, men of science, manufacturers and users, as to the explanation of certain phenomena in the non-ferrous metals. He thought that at the present moment they were getting to a position of having some solid ground beneath them, and approaching to an agreement on certain points which might make a nucleus upon which to build. One problem related to the presence of oxygen and oxides in copper and its alloys, and another important question was in relation to the heat treatment of metals. He did not think that too much importance could be attached to this latter problem, which he regarded as of vital importance. On some of the main points members of the metal industry were more or less agreed, and he hoped that that stage of agreement having been reached investigation would in future be continued upon definite lines. He would like to impress upon investigators the danger of basing their theories upon one or two individual investigations. It had been shown that while a particular experiment would give a certain result, the same experiment with a very slight variation either in the composition of the material or in the heat treatment would give an entirely different result, and therefore it was necessary to repeat experiments many times before making any definite statement as to conclusions. With regard to the influence of oxygen upon electric copper as compared with tough copper, results obtained were entirely different, and he would go as far as to say that the variation in copper alone was almost as great as the variation in copper alloys. In regard to the science of metallography all those engaged in practical work had arrived at the conclusion that that science was not yet sufficiently appreciated in works practice. The microscope furnished a valuable aid to research work, and the practical man would do well to utilise the microscope to the fullest extent.

A number of interesting papers were read, including the following:—"Magnetic Alloys Formed from Non-magnetic Materials," by Alexander D. Ross; "Some Common Defects Occurring in Alloys," by Cecil H. Desch; "The Heat Treatment of Brass: Experiments on 70: 30 Alloy," by G. D. Bengough and O. F. Hudson; and "Metallography as an Aid to the Brassfounder," by H. S. Primrose. These papers will be dealt with in our next issue.

Machine Moulding.

By J. R. Moorhouse.

In the selection of moulding machines for foundry use, the conditions under which they will operate and the range of patterns to be used must necessarily be considered, in order that the machine most suitable for the purposes may be adopted. There are types of machines that lend themselves more particularly to certain work, and for that reason are preferred. For deep patterns with small draft a stripping machine would be used, or for shallow patterns a machine adapted to use draw plates would suffice. If the sand is required to be power-rammed, the jarring machine is preferable on the deep patterns, and the squeezer type of machine for shallow work. These types, again, may be subdivided, each class having a sphere of service in which they may be used to special advantage. Fig. 1 shows diagrammatically the three principal methods used in the various types of machines for stripping patterns from the moulds. No. 1 has reference to roll-over and rock-over types; the mould being in the position shown, favours a clean draft of the patterns from the mould. No. 2 can be used on small, well drafted patterns, and works faster than

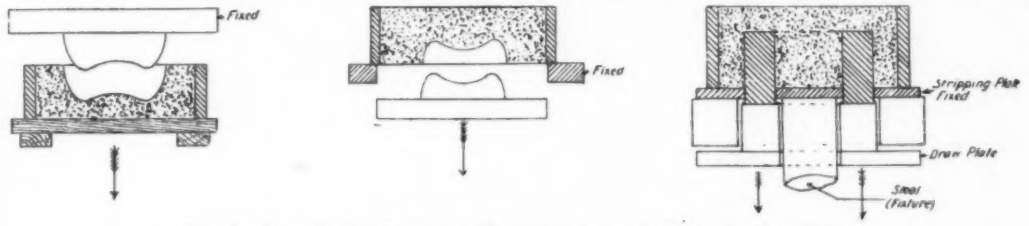


FIG. 1.—THE THREE PRINCIPAL METHODS USED IN DRAWING PATTERNS.

No. 1. With flasks too shallow, however, there is a tendency for the mould to drop when drawing the patterns, due to the inverted position of the mould. No. 3 refers to stripping machines; perfectly straight patterns of any depth can be used on this type of machine, but the cost of mounting the plates and stools is an objection raised against it, though this may be materially reduced by the use of wooden plates. (See "Wooden Patterns and Plates for the Jobbing Foundry," FOUNDRY TRADE JOURNAL, December, 1909.)

With machines that draw the patterns, as attached to the plate, it is essential that the stripping apparatus be accurate in the lift or drop, and a test should be made previous to the mounting of the patterns to ascertain if the machine be correct, otherwise the plate may be wrongly blamed. One method of testing the machine is to secure a try-square to the frame upon which the pattern plate is secured. A mechanics' scriber block is then used, supported by the stripping device, and the point is made to touch the blade of the square. Upon this being raised, or *vice versa*, the scriber point should fair with the blade of the square the full length of the stroke. With the roll-over and rock-over types of machines it is advantageous to use a levelling device, to compensate for any unevenness of the flask and bottom boards. However accurate the machine may be in regard to the draft, it is impossible to draw the patterns correctly, unless there be some means of compensating for the irregularity of the flask and bottom boards. A simple device used by the writer is shown at Fig. 2, and can be attached to existing machines providing the lift is sufficiently deep to allow for it. A represents the plate or frame of the stripping apparatus, in which a hollow is turned to receive the ball pin B. Upon this a cramp plate C is made to fit, and accurately encloses the ball to half its diameter. This plate grips the ball with a pressure exerted by the springs, shown on the studs E E. Upon the frame D are bolted the three sets F, F, F, to which is firmly secured the stock of the ball pin B. It will be evident that the frame D is free to oscillate in the knuckle, and governed by the pressure of the springs, the friction on the ball will support the pattern-plate in any required position. In operation the stripping device is raised hard against the bottom board, the sets F, F, F, adjusting themselves to any unevenness that may be in the bottom board or flask, so that a clean and perfect draft of the patterns is obtained.

With those types of machines that roll the plate over and the squeezing of the mould is effected in this position with the bottom boards located, there is no necessity for a levelling device, as in this instance the stripping is the reversed motion to the squeeze, and no change of position occurs in the interval of the ramming and the squeeze, so that providing other details are correct, a clean drop of the mould is assured.

If it is the practice to strip the pattern plates shown in principle in No. 2, Fig. 1, the mould being raised off the plate by means of studs engaging with lugs on the flask, it is preferable to use three to four studs. At the best this method of stripping the mould is unsatisfactory and not applicable to deep patterns or those intended to give fine outlines. The reason is obvious, when it is considered that the lugs on the flask must remain parallel to the joint of the plate, as also the studs that raise the flask off the plate. Should this not be the case, and unless there has been considerable draft given to the patterns, the more delicate portions of the mould will be broken away.

To ascertain whether the studs strike the lugs on the flask evenly, the plate is cleaned and the joint of the flask made to rest level on four pieces of stout note-paper placed on the pattern plate at the four corners. The stripping apparatus is then raised, and if the lift be even the four sheets of note paper will be freed from under the flask at the same moment. Should one or more pieces be removable, the flask still nipping the remaining pieces of note-paper, this will show that the lift is not even, and must be adjusted to

fulfil the afore-mentioned condition. The difficulty however, lies in maintaining this condition in practice, and where this principle is required for operating pattern-plates, the drop-plate type is much to be preferred, and quite as quick in the production of moulds; the order is simply reversed, and in place of the mould being raised off the pattern-plate, the mould remains a fixture and the pattern-plate is dropped away from it. The objections, as above noted, are obviated by the use of the latter machine.

In cases where deep patterns are rammed by a squeeze, either by hand or power, a form or contour head should be used to avoid hard and soft spots in the ramming. This form-piece approximately follows the outlines of the pattern, and is used to give the first squeeze to the mould, and afterwards the flat ram is applied to complete the mould. The reason for this double squeeze is that the sand remains the hardest at the squeezer head, and gradually softens out as the thickness of sand increases, so that the prominent parts of the pattern receive a hard portion of sand, and the depressions in the pattern a somewhat soft supply, depending entirely upon the depth and shape of depression.

With the jarring machine this is quite the reverse, the sand remaining the hardest around the pattern and gradually softening out as the distance from the pattern increases. This valuable feature follows more correctly the hand-ramming, and its application to the ramming of moulds has a wider field than with any other type of machine. It is commonly applied to the ramming of moulds up to 8 tons or more in weight, and is now combined with the rock-over type of stripping machine.

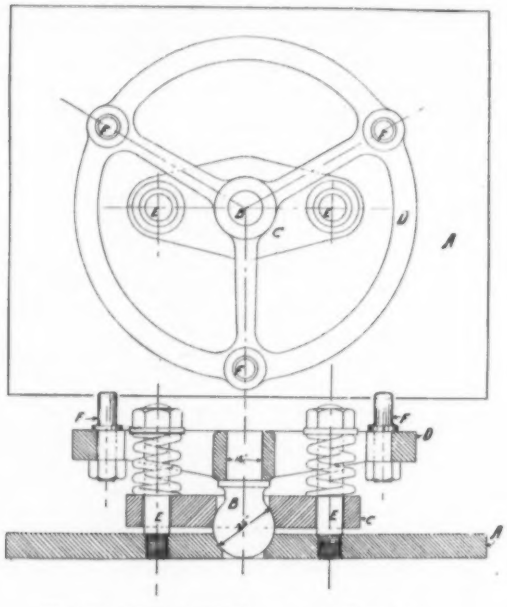


FIG. 2.—AUTOMATIC LEVELLING DEVICE.

Materials Used for Moulding Machines Pattern Plates.

The general principle of mounting patterns on plates being understood, there should be no difficulty in rigging up moulding machines with plates. The difference is mainly in the manner in which such plates are secured to the machines, and the way in which they are operated by the various types. As a matter of fact, with snap-flask work the cheapest work can be accomplished by simply using a hand-squeeze machine on loose pattern plates. It will be only necessary to describe here the method of making plates as is in general use, and leave the method of attaching these to the various types of machines, as this information is always given by the makers.

The materials used to construct patterns for plates comprise a considerable variety of metals and compositions, the question as to quantity generally governing the quality of the plate. When there are many thousands of moulds to be made from the one plate, it is economical to employ the highest grade of material and workmanship. Such a plate should be made of steel, from ¼ in. to 1½ in. thick, according to the size of flask used. These are planed true and parallel, the holes for the pins on the flask being bushed with hardened machine steel. The patterns should be made from the best bronze and be finished by chasing to give them a superior finish, which will facilitate a clean draft of the patterns from the mould. The mixture for the metal may be:—Copper, 80 per cent.; tin, 15 per cent.; and zinc, 5 per cent., which mixture is used principally on fine-art work of intricate design. A cheaper metal used in general practice with good results consists of copper, 60 per cent.; zinc, 35 per cent.; and lead, 5 per cent.

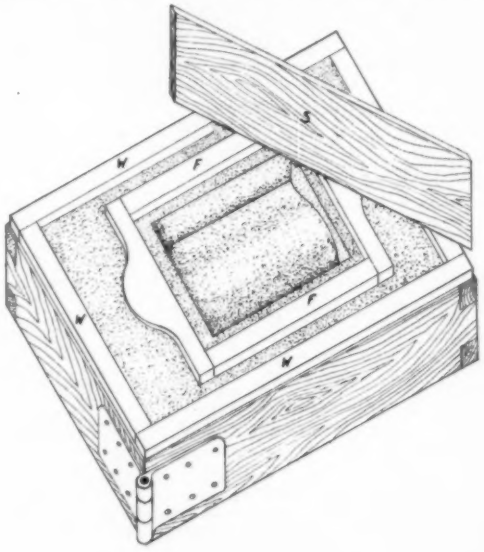


FIG. 3.—FORMING A PATTERN PLATE IN THE MOULD.

Where plates are to be manipulated by hand, as is commonly done on the hand-squeezer type of machine, aluminium is an excellent metal to employ, on account of its lightness. It has a volume approximately three times that of brass, and is, therefore, the cheaper metal to use. It is superior to white metals, being harder and not liable to lose shape in handling. It is specially adapted for plates cast in the one piece with the patterns, and can readily be worked with the file. It is advisable to harden aluminium pattern-plates by the addition of zinc or copper. Mixtures of two parts aluminium and one part zinc, or 93 per cent. aluminium and 7 per cent. copper, make plates about as strong as cast iron, considerably lighter, and

free from the corrosion which iron pattern-plates are subject to.

For large patterns in use with the stripper type of moulding machine, and where the patterns are of wood and rammed up by hand, it is good practice to protect with sections of metal, those parts that are liable to be scored by the rammer, for which purpose the aluminium-zinc-copper alloys are specially adapted. These alloys are to be also preferred for making any loose members, such as ribs or bosses, that are to be left in the mould after the principal member has been withdrawn. Especially is this an advantage on the jarring machine, as a loose heavier metal member would be more liable to displacement through the jarring of the moulds.

Cast-iron pattern plates are used extensively for moulding machines, on account both of cheapness and the rough handling they will stand without being damaged. The patterns should be of close-grained metal and treated with beeswax and plumbago to give them a smooth surface, and also to prevent corrosion. For pattern-plates in constant use it is necessary to repeat this treatment once a week, to maintain the plates in thorough working condition. Cast iron, though having a wide field of application for pattern plates, is unsuitable for delicate designs, where the imprint of the pattern must be clearly defined.

As regards white metal for pattern plates, these are economical on jobbing moulding machine work. From one customer's pattern can be obtained any number of patterns necessary to serve a plate for use on the machine, and the original size of customer's pattern be still maintained. A metal for such work would consist of one part tin and one part lead, by weight. The disadvantage with this metal is that the plate, on account of the soft nature of the material, cannot be used in the piece with the patterns, it being necessary to attach them to either metal or wood plates, so that they will be kept in true shape. White metal is also extensively used in conjunction with composition match plates, and for this purpose any good babbitt metal can be used. A point to be borne in mind when making a master pattern, from which it is intended to make metal patterns for mounting on plates, is the amount of contraction necessary to give the final castings correct dimensions. The following table shows general allowances per foot :—

Allowance on Master Pattern.	*Metal Forming Plate Patterns.*	*Final Castings.*
Inches.		
0.2875	Brass	Cast Iron or
0.20	Cast Iron	Malleable
0.35	Aluminum	Iron.
0.30	Aluminum Zinc or Copper	" "
0.125	1 part Tin & 1 part Lead	" "
0.375	Brass	" "
0 2875	Cast Iron	" "
0.4375	Aluminum	" "
0.20	1 part Tin & 1 part Zinc	Brass
0.3875	Aluminum-Zinc or Copper	or Steel.

These allowances do not take into account the finish or any machining that may be required on the pattern castings, as is often necessary to produce a clean and smooth working surface on the patterns. In instances where a customer's pattern is used to produce patterns from which a pattern plate is cast, an additional allowance of $\frac{1}{4}$ in. must be made if the patterns are cast in the tin and zinc mixture.

Composition and cement pattern plates are used with many types of machines, particularly the roll-over squeezer, and give considerable wear before any signs of failure become apparent. Usually metal patterns are used in the composition, having been previously finished and made workable for moulding. A mixture can be made from two parts cement, two parts plaster of Paris, and one part sharp sand. These are thoroughly mixed dry and put through a hair sieve, water being added in the proportion of three to four of the mixture by measure. There are numbers of mixtures in use for match plates, each claiming some special advantage. The writer, however, has given mixtures in which he has had experience, and for oil matches recommends litharge one part, linseed oil four parts, and fine sifted sand 24 parts. These match plates require 12 to 24 hours' standing before being used.

Making Metal Pattern Plates.

The range of work that comes on moulding machines necessitates numerous methods and arrangements for mounting patterns. A form of plate suitable for use on the hand or power squeezer machines is that which has the respective half-patterns secured on either side of the plate. This will allow, if necessary, for both drag and cope to be squeezed at the same moment. These plates may be made in any of the materials afore-mentioned, and in many foundries it is the practice to cast the patterns and the plate in one piece. For general work this is sufficiently accurate, and cuts down the costs of machining to a minimum. The plates are also simple to make and can usually be made and finished by the moulder. To produce these, a frame F, Fig. 3, is made of wood to the required shape and dimensions of the finished plate. A flask large enough to allow for this frame to be moulded is placed on a true-level board, and the frame is temporarily placed in to give the correct position of the patterns. The patterns being set and the frame removed, they are rammed up in the ordinary manner, the flask is rolled over, and the cope part with the mating half-patterns located are then rammed up and the mould completed. Assuming the cope to be removed, the frame F is placed on the joint of the mould in true relation to the patterns, as shown. Strips of wood, W, of a thickness equal to the thickness of the plate or frame, are also placed on the joint of the flask. It will be seen from Fig. 3 that it is only necessary to fill in the intervening space with sand, and strickle the surface away by means of the strickle S. After

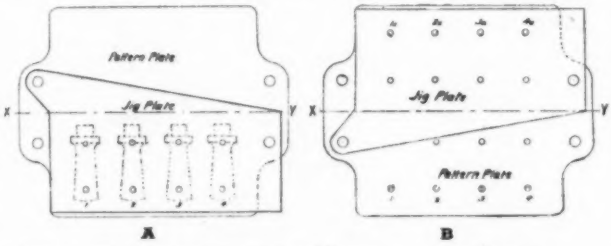


FIG. 4.—SETTING PATTERNS BY MEANS OF A JIG PLATE.

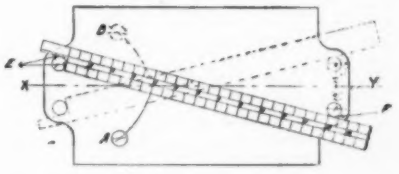
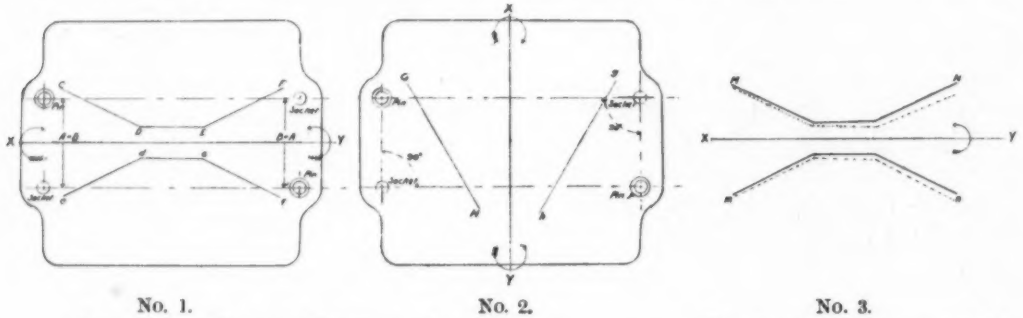


FIG. 5.—MARKING OUT A PATTERN PLATE.

the runners are cut, the mould may be closed and weighted ready for casting. The casting, when made, is then filled and trimmed, and the holes for the pins on the flasks also drilled. If the plate be of cast iron it is heated gently and given a coating of bees-wax, and before this is allowed to get thoroughly cold, graphite or plumbago is rubbed over the patterns to give them a smooth surface. Where possible, the patterns should be lightened, as this will make the plate easier to manipulate. Provided a margin of metal about ¼ in. be given, the patterns may be cored and afterwards plugged with wood. It is also essential for accuracy to see that the pins on the flask in which the plates are made are a correct fit in the mating half-flask; otherwise any looseness would be shown in the final castings by over-shot joints. The patterns themselves should likewise be jointed correctly to favour as clean a draft as possible. Before making any quantity of moulds it is usual to have a trial cast from the plate, so that any discrepancy can be corrected before many castings are made.

For strictly accurate work, and patterns with delicate outlines, the plates should be made separate from the patterns. They should be machined true and parallel on both sides, the holes for the pins on the flasks being bushed with case-hardened machine steel, to insure the flask keeping a snug fit on the plate. The pattern is jointed in a manner best suited to give a good lift, and particular care must be taken in providing the necessary amount of draft so that no point will be undercut. The pins in the pattern are made long enough to protrude through the plate and engage with the mating half on the reverse side. The socket half-pattern has the holes drilled clean through, so that it can be used as a jig to drill the plate, as likewise for the tap holes to secure the pattern to the plate. In instances where the cope and drag work from one side of the plate, it is more difficult to locate the patterns, due to the double setting. To accurately lay out this type of plate requires extreme care, and to give reliable results it is preferable to use a drilling jig and locating pins in the half-patterns. The patterns to be mounted are first carefully cramped together and drilled for the locating pins. One of these half patterns is then placed on a plate that previously has been fitted to the pins on the pattern plate and used as a jig to drill the plate, which is then replaced on the pattern plate and so transfers the correct position of the locating holes as obtained from the pattern. This is shown in Fig. 4 at A. These holes having been drilled, the plate or drilling jig is reversed, as seen at B. It will be evident that these holes as drilled must give an accurate means of setting the patterns, so that they shall be free from any offset in the castings. The same principle applies to the use of separate cope and drag plates. It is not necessary to make a new plate for the setting of additional patterns, as the jig will serve for a considerable number of holes being drilled into it before it becomes necessary to substitute another plate. It is necessary, occasionally, to lay out on the plate the positions of the patterns, and for this purpose a rule, shown in Fig. 5, will be found very handy. Any type of rule may be used providing both faces are accurately marked. The steel two-foot rules, as generally served to pattern-makers, can be advantageously used by making a notch at the end, as shown at E. This notch shoulders the rule hard against the pins on the plate, so fixing a position in the one direction, and if it be brought to bear hard on the partner pin, as seen at F, will give a position on the plate that can very simply be transferred over the line X Y by introducing loose pins in the sockets, and similarly placing the rule hard against them. These loose pins are necessary for placing in the sockets of the plate, so that the rule may not only be set by them, but the rule may be traced in any radial position, as marked at B on the one side of the line X Y and at A on the other. It will follow that, given a point and a line on either side of the centre in accurate accord with each other, it remains to lay out the position of the patterns from the given points, which is now comparatively simple. Starret's or Brown and Sharp's combination set will be found very handy for use in setting out the position of patterns on plates. But, as previously mentioned, the difficulty is not only in laying out the plates, but also in securing the patterns to the assigned positions, as can be inferred from the difficulty in drilling a hole a few thousandths of an inch to the lay-out marks, which is essential to give the patterns their correct location and to ensure the castings free from offsets. The use of a jig plate, as previously described, allows the positions to be located within a few thousandths of an inch without much difficulty. The plates shown in Figs. 4 and 5 are worked with flasks having staggered pins. This is an advantage, because the flask can be used either in the length or width of the plate. If the pins are fixed in the centre of the flasks, then the pattern plate, drag, and cope half-flasks will each have a socket and pin attached. This allows the plate to be operated in one direction only, and in a line with the centre of the pins. By the use of a loose pin of the same diameter as those used on the flasks to place in the sockets of the pattern plate, the flasks can be worked as with staggered pins, and similar to Nos. 1 and 2, Fig. 6.



No. 1. No. 2. No. 3.

FIG. 6.—TWO WAYS OF WORKING A PATTERN PLATE.

FIG. 6A.—ERROR CAUSED BY BAD FITTING OF PINS.

The time taken in placing the pin for every half-mould made is, however, an objection to this practice. To drill the holes in the flasks correctly so that they may all work off the same plate with the same precision necessitates the use of a jig. In laying out the position of the holes for staggered pins, care must be taken to observe that they come on strictly parallel lines, as at Nos. 1 and 2, Fig. 6, or otherwise when the cope and drag come together a condition of things similar to No. 3 would occur. If the plate and flask be correct, the lines M N, *m n*, should cover the dotted lines. The jig used for drilling the position of the holes is machined true and parallel, the holes for guiding the drill are bushed with case-hardened machine steel. A good rule is to add ¼ in. to the diameter of the pin used, for the length of the bush, to prevent the drill from springing. The snugs on the flasks should be spot-faced on both sides. This is essential to assist in keeping the pins parallel with each other. The shoulder on the pin will sit hard on the one side, and the nut will have a true face to turn on the other. Providing the pin is given a tapping fit in the hole of the snug, there is no reason why, when bolted down and made secure, all the pins should not be thoroughly interchangeable with any flask or plate drilled from the same jig. Whatever size of pin be used, the holes for the sockets should be of a stan-

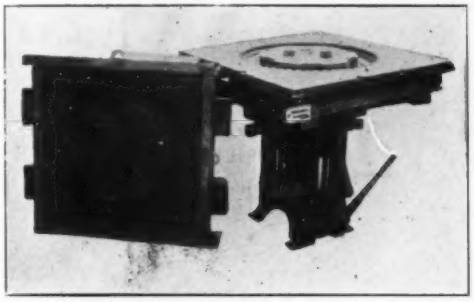


FIG. 7.—GEAR-WHEEL MOUNTED ON STRIPPING MACHINE.

dard reamer size, and the clearance turned off the pin. This will be about 0.008 for pins up to 1 in. in diameter, using two pins only; if three or four pins be used the clearance must not be less than 0.01. To keep interchangeable flasks as such needs care in manipulation in the foundry. They should never be struck with a hammer, but when inclined to jamb a little flake graphite rubbed on the pins will help them. There is always a tendency for them to rust and jamb up, so that an occasional overhauling is really necessary to keep them in good working condition.

Forming Composition Match Plates.

With composition match plates, it is necessary to run the mixture into frames that have previously been fitted to the flasks with which they eventually have to work. These frames can be made from any of the metals previously mentioned, and for hand operating, as is customary on hand squeezer machines, the aluminium-zinc or copper alloys are specially adapted because of their lightness. If only a limited number of castings be required wooden frames may suffice. These frames must be deep enough to give a reasonable thickness of the composition from the highest point of the pattern to the back of the plate, as otherwise it is liable to crack at this point. If the back plate is cast in one piece with the frame, then a series of dove-tail sets can also be cast on the plate to give the composition a further anchorage. In any case the sides of the frame must be dove-tailed to hold the mixture in position. These frames are carefully fitted to the flasks with which they operate, one frame being necessary for the drag, and one for the cope part. Two similar sets of patterns are also necessary, to be placed in the respective cope and drag parts.

Assuming these already supplied and finished for moulding from, an oddside is taken and fitted to the drag part, in which is bedded one set of the patterns. These must be accurately set so that no part shall be undercut and the joint made to the best possible advantage to favour a clean casting. The drag part is then placed upon it and rammed up harder than is usual for regular work, a bottom board is placed on the drag and the whole lot rolled over. After the oddside has been withdrawn the joint is finally corrected and parting sand dusted upon it. The cope half is then placed in position and rammed up in a similar manner to the drag. It is then necessary to remove the cope from the drag part, this being carefully done so that the mould is not damaged in any way. Should the lift be a bad one, a fresh start must be made, because if mending up be resorted to, it is very probable that the finished plate will give a fault on all the castings produced from it. If the lift is a good one the patterns are allowed to remain in the drag, and the remaining set of patterns is placed in the impression in the cope part as made by the drag patterns. The frames are then placed on their respective cope and drag parts, and weighted ready for pouring with the mixture. If the frames be of wood it is preferable to leave them open, in which case no difficulty will be met in seeing that the mixture runs up solid in all the depressions of the patterns, the mould is allowed to stand undisturbed for half an hour, after which the surplus composition is strickled off.

The back plate is not secured to the frame until it is thoroughly set. With metal frames provision is made at the four corners of the frame to pour the mixture, and when this is run into the frame it should be fed with a rod for a few minutes to work out any air that may have got penned in during the running of the composition. A few hours must elapse before the frames are removed, when it will be found that the patterns are firmly embedded in the composition; the sand is washed off the plates, and then set aside for a day or so to dry in a warm room. If the patterns are bulky it will be necessary to secure them by bolts to the back plates; for this purpose the holes have been previously drilled in the patterns, which are then continued through the back plate, and finally bolted and secured to the frame. The plates are given a coat of shellac varnish, or a coating of linseed oil, which is dried by a gentle heat applied to the surface of the composition.

In place of composition, litharge may be used if desired, and the plates formed in a similar manner as for the above mixtures. White metal can also be adapted to form this type of plate. The only difference in the two is that with white metal the patterns are not left in the mould, but used only as a means of forming the mould in which the metal is poured after the frames have been placed on their respective half-flasks. The depth of the recess in the frames need only be about $\frac{5}{16}$ in. or $\frac{3}{8}$ in. The back of the frames are cored, or drilled, in such a manner that will give an anchorage for the metal.

A trial cast should be made to correct any error that is liable to develop in the cooling of the plates; this can be readily corrected by a little filing and scraping of the match plates. In practice the metal does not always set to the same advantage, and thus will require attention after casting.

Stripping Machine Pattern Plates.

It has been mentioned that the stripping machine is capable of working patterns of any depth with comparatively little draft, and in most instances without the use of any vibratory attachments. The cost of preparing the plates, however, is a drawback to its use, as these may for some jobs cost as much as the original price of the machine. In instances where many thousands of moulds are required from patterns that are practically free from draft, the cost of these plates is quickly compensated for, not only because unskilled labour is enabled to turn out more work than the skilled moulder, but also on account of an advantage in all the castings being much more uniform and consequently less trouble in the machine shop. With castings that have to be placed in jigs for machining purposes, it is important that all castings be alike, as otherwise some important part of the casting may fail to come up to the machining allowance. A great saving may be effected in the mounting of these plates by using wooden strippers, or where considerable numbers of castings are required, by the use of babbitt metal as a means of forming the metal plate to the shape of the patterns, in place of filing. This plate is made to have a clearance all round the patterns of $\frac{3}{8}$ in. to $\frac{1}{2}$ in. to receive the babbitt metal; a projection is also cast on the under side to come within $\frac{1}{16}$ in. of the patterns, to keep the babbitt in place. It is important that a clearance be left between the stripping yokes and the underside of the stripping plates, as this is necessary to allow for a certain amount of sand accumulating on the yokes, which would jamb the machine if not allowed for. After the frame has been secured in its correct position, the pattern is slipped through the recess and secured to the stripping yokes, the distance piece coming between the yokes and the pattern being made to conform to the outlines of the pattern. In this way a clean strip is obtained. This is well greased with thick tallow and the underside of the stripping frame plugged with fireclay, to prevent any escape of the molten babbitt metal. After the plate has been poured the pattern is stripped and the babbitt scraped to allow a small working clearance. A very serviceable plate is obtained in this manner that will give entire satisfaction.

With the use of wooden stripping plates, a still further economy is effected. In Fig. 7 is shown an example of a gear wheel mounted on a simple type of stripping machine, the pattern being shown already stripped and the mould placed to the left of the machine. This plate was completed in 10 hours, and held good for 500 moulds before any repairs were necessary. In instances where two machines are used, one for the drag and one for the cope, the patterns are placed accurately in relation with each other by first fitting the plate to the flasks or snap. The half-patterns are then placed on the plate and a scriber line marked around them. The plate is cut to these lines, and made to fit the patterns loosely, the two plates are then placed together by means of the pins and sockets upon them, and the recess cut in the one plate marked on the other, which when cut out will set the patterns accurately on the machine.

FIG. 1.—VIEW IN THE FOUNDRY OF THE GOSFORTH FOUNDRY CO., LTD.

Innumerable examples could be given of the saving effected by the use of moulding machines, which are now made to suit most grades of work, but in order to make the most of the machine, of not the least importance is the method adopted in the mounting of the patterns to the best of advantage for moulding.

New Works of the Gosforth Foundry Company, Limited, Dronfield, Sheffield.

The Gosforth Foundry Company, Limited, is the modern outcome of a small malleable ironfoundry business, established about thirty years ago. It passed in 1897 into the hands of Mr. Wm. Prestwich, who is managing director of the Company, and purchased the land on which the new works have been erected. Besides the ordinary business of malleable ironfounders, the firm have for some years devoted considerable attention to the making of Ewart's & Gray's elevating and driving chains. This now is one of their principal departments.

The works are approached through a gateway, on the left of which are the offices, which are lighted throughout, as are also the works, electrically. The foundry, which is 80 ft. by 50 ft., is covered by four bays, the roof being lighted entirely from the north. There is the usual coal-fired muffling furnace, and two moulding machines are also installed. The greater portion of the work is, however, hand-moulded, and for most of the small parts metal patterns are used. Buildings are erected adjacent to the foundry for the accommodation of core-makers, rumblers for cleaning work, and as grinding and fitting shops. The various machines are operated from line shafting. The cupola has a melting capacity of about two tons per hour, blast being supplied by a Sturtevant blower, driven by belt from line shafting. Over the finishing shops are the pattern shop and patterns stores, as also the metal pattern-making department, this last being served by a coal-fired melting furnace.

The annealing shop is covered by a corrugated-iron roof supported upon brick pillars. The furnaces, five in number, are arranged for top draft, and have each a holding capacity of about three tons. The furnace stack is 60 ft. high by 7 ft. diameter at the base and 4 ft. 6 in. at the top. Power is supplied by a Tangye gas engine of 28 h.p., working on producer gas. The dynamo for lighting is driven by belt from a countershaft. The Company have ample land at their disposal for further extension, upon which it is proposed to erect additional shops at a later date.

FIG. 2.—ANNEALING FURNACES AT THE WORKS OF THE GOSFORTH FOUNDRY COMPANY, LIMITED.

Cast-Iron Borings in the Foundry.

By briquetting cast-iron borings they can be used in the cupola in the same manner as scrap or pig-iron. A method suggested is as follows:—Use 50 lbs. of a briquetting compound to 1 ton of borings, mixing thoroughly in a dry state. Add sufficient water to temper this mixture, making it of about the same consistency as an ordinary core-sand mixture. Next take a box taper mould of ordinary boards, measuring, say, 6 in. by 12 in. at the bottom and 7 in. by 13 in. at the top, which will make a block weighing from 50 to 55 lbs. The taper mould is preferred, as it enables the block to come out of the mould more easily. After filling the mould with the mixture of briquetting compound and borings, it can be compressed with a small hydraulic or moulding machine or by a compressed air or hand press, or it can be rammed by hand equally well. The blocks should then be placed in a temperature of approximately 75 to 80 degrees and permitted to remain in that temperature for about 48 hours. They will then be ready for use and can be dropped in the cupola in the same manner as pig-iron. The suggestion is made that the briquettes should not be used on the bed of the cupola, but in the charges following. For instance, the pig-iron can be placed in the cupola in the usual manner, then the quantity of scrap desired and the quantity of briquetted borings.

The Effect of Superheated Steam on Cast Iron and Steel.*

(*Continued from page* 418.)

JOHN PRIMROSE.—During the past eight years the writer has been in close touch with many plants, containing upwards of fifteen hundred installations using superheated steam, and in a position where troubles would be promptly reported to him. Almost without exception these plants use cast-iron fittings in their pipe connections. The fact that no one of these plants has reported troubles with its fittings is in striking contrast to the comparatively few instances where superheated steam has been charged with being the cause of trouble with cast-iron fittings. In order that there should be no doubt about the absence of trouble due to superheat, letters were written to ten concerns known to have been passing superheated steam through cast-iron fittings for the past eight years, at from 100 to 150 degrees superheat, asking the following questions:—(1) Are not the tees, elbows and valves of cast iron in the branch and main steam lines leading from the boilers? Seven answered yes, two replied that some fittings and valves were of cast iron and some of cast steel, and one replied that while the fittings were originally of cast iron some tees had been changed to cast steel, but stating positively that the change was not made because of any ill-effects of superheated steam. (2) Are fittings of extra heavy or standard weight? Nine replied that they used extra heavy fittings, and one standard weight. (3) What steam pressure do you ordinarily carry? One used steam pressure of 100 lbs., six used 150 lbs., one 165 lbs., one 185 lbs., and one 200 lbs. (4) Have you ever noticed any injurious effect of the superheated steam on valves or fittings? Eight answered no, one that no trouble was experienced in fittings, but that valves with cast-iron bodies and brass seats were difficult to keep tight, and one reported no trouble further than the baking of a hard deposit on inside. (5) Have you ever found it necessary to replace any of these valves or fittings with cast-steel? Eight answered that no fittings or valves had been replaced on account of superheated steam. One answered that they had replaced no fittings, but some globe valves, and one answered that they were replacing some fittings with cast-steel, but upon further inquiry it was found that this was not because of the ill effects of superheat, but because the steam mains were being changed to contain Van Stone joints and they wished to change the fittings to standard length, and deemed it advisable to use cast-steel. (6) Of what material are the gaskets in the steam line? Seven use corrugated copper or bronze, two sheet packing, and one asbestos.

There is nothing extraordinary in the fact that several cast-iron fittings have failed when passing superheated steam. The failures were probably due to inferior metal, or to strains developed by expansion or contraction of the pipe lines, as suggested by Professor Hollis and Mr. Mann. These are much more plausible theories than that superheated steam at a temperature of 500 degrees to 600 degrees Fahr. has any effect on the metal. In investigations by Mr. Outerbridge and Professors Rugan and Carpenter on the growth of cast iron when repeatedly heated, their experiments were started at 900 degrees C., or 1,652 degrees Fahr. Such instances as the growth of grate bars, etc., are all at temperatures far exceeding anything used in superheated steam work for power plants.

The writer's experience with a great number of steel fittings used for pressure parts of superheaters exposed to hot gases, has led him to conclude that the metal in steel-castings is anything but satisfactory for fittings. It unquestionably has greater tensile strength than cast-iron, which appears to be its only advantage. On the other hand, it is difficult to get steel castings sufficiently homogeneous to hold the pressure. A large percentage of castings are "doctored" before leaving the foundry, but new openings frequently develop on test after machining, and even after the castings are in place, causing the charge to be made that the castings have not been tested before sending out. The fact is further evidence of strains developing in service, other than those produced by internal pressure, which open up cavities or spongy places not discovered by shop test. Steel castings vary greatly in toughness, as shown by the great variation of elongation on test; others are so hard that machining is very difficult. While they can be bought on very careful specifications to guard against these faults, there is always the chance of porosity. The high tensile strength of the steel is not a necessity, and cast-iron made to careful specifications is amply strong. It machines well, is not porous, and can be relied on to hold the pressure.

H. S. BROWN believed the troubles with cast iron would be eliminated if the temperature could be kept constant, and further said:—I think the discussion boils down to this, that under certain conditions steel castings will give a more satisfactory performance than cast iron. The company with which I am connected has found it necessary to replace a large number of cast-iron fittings with steel castings, where superheated steam was used; and the performance of these steel fittings, under the same conditions under which the cast-iron fittings were working, has been satisfactory. In a large number of other plants where cast-iron fittings are used with saturated steam, the design of the piping is such that the stresses set up on account of expansion and contraction are very much worse than in this system; and we do not get into troubles as we did in using superheated steam. It may be that steel fittings will form a more practical and less expensive way of taking care of the conditions set up by the use of superheated steam than elaborate precautions in the way of expansion joints and the like.

E. H. FOSTER.—Cast iron is much too useful a metal to receive general condemnation for steam-pipe fittings, whether for superheated or saturated steam, without very good reasons, and the writer is firm in the opinion that such reasons have not yet been advanced. No instance has yet occurred where the weakness has not been readily explained by the poor quality of the iron, or by lack of provision for expansion and contraction without straining the metal. The many instances where cast-iron fittings are habitually subjected to steam of varying degrees of superheat up to final temperatures close to 1,000 degrees F. leave no doubt that good cast iron is equal to, if not better than, any other metal for making steam fittings for superheated steam as well as for saturated steam, especially in smaller sizes. The suggestion that better provision should be made for free expansion and con-

*Discussion on Papers read before the American Society of Mechanical Engineers.

traction of steam pipes, is very much to the point. More care applied to this feature of the design of power plants would remove entirely from the shoulders of cast iron the odium of being unsuitable for carrying superheated steam.

L. B. NUTTING stated that superheaters installed by his company nine years ago, and since then in constant use, have caused no trouble and have not changed their dimensions. These superheaters were made entirely of cast iron, the tubing having a smooth bore and corrugated exterior. He also reported a great many superheaters installed and in operation delivering steam at a temperature of 1,000 degrees F. On these the users have employed, without any distortion or without any evidence of weakness developing, standard makes of cast-iron valves (globe valves and angle valves) under 1,000 degrees final temperature. But the temperature is maintained at 1,000 degrees, without a variation of 25 degrees. These illustrations seem to trace the cause of the trouble with cast-iron fittings directly to widely fluctuating temperatures. In regard to the suggestion that provision should be made to obviate troubles from varying temperatures on cast iron, Mr. Nutting asked, why not make provision to keep the temperature constant. The art of superheater construction has advanced to such a point that a uniform temperature should safely be counted on.

ANDREW LUMSDEN.—In one case we have eight boilers of the Babcock & Wilcox type, equipped with heaters part of which were made and installed by the boiler company. These boilers were all connected to one 12-in. main through long radius bends, valves, tees, etc. On the superheaters installed by the boiler company there were usually 150 degrees of superheat and on the others about 90 degrees. When this plant had been in service about two years some of the fittings in the main were found to leak just back of the fillets and small cracks were discovered extending around one side of the tees. Some long bolts were made to go the whole length of the tees and through the end flanges, using them to make the joints. Steel tees were also ordered of the same dimensions as the cast iron ones to replace all the fittings in the main. When the old fittings were removed, however, it was found they were from $\frac{3}{8}$ in. to $\frac{1}{2}$ in. longer than when first installed. This is a turbine station, and they have had trouble with the admission valves on some of the turbines, those directly opposite the boiler carrying the 150 degrees superheat giving by far the most trouble. At another plant where they have Babcock & Wilcox boilers, Curtis turbines, etc., they have carried 150 lbs. steam pressure and 150 degrees of superheat for about six years, with cast-iron fittings, etc., and have had no trouble with the fittings. The valves have given them some trouble with loose seat rings and by being badly cut, and some of them have been replaced.

JOHN C. PARKER.—Professor Hollis draws attention to the necessity for greater allowance for expansion in piping for superheated steam. This is important and where sufficient flexibility cannot be put into the design expansion joints should be installed. My experience accords with his statement that cast-iron fittings have been largely and successfully used for superheated steam. I believe there is no connection between the troubles which I have been cognisant of with some designs of superheaters and the expansion of the steam mains. I believe the troubles have been due solely to fluctuations in temperature and temperature shocks caused by frequent injection of condensed steam from incorrectly designed superheaters. I recently went into a plant where a superheater had been in use for about four years. It was an independently fired superheater, and the engineer had had so much trouble with piston rings in an engine with poppet valves designed especially for superheated steam, that he had cut the superheat from 600 degrees F. to 500 degrees F. and then to 400 degrees F. He had his ideas centred on the point at which the trouble occurred (the cylinder and rings), and would not believe that it was due to fluctuations of temperature. I finally pinned him down to the statement that "the temperature could be controlled perfectly, but you had to watch it like a cat." There is a superheater in the market that uses cast iron to protect wrought-iron tubes. I have seen some of these removed from boilers on account of overheating and, while the cast iron had been red hot it had cracked less than some steam-pipe fittings which had been subjected to water jets and fluctuations under 600 degrees F.

ALBERT A. CARY said that after investigating a number of plants having trouble with the use of superheated steam, he had been led to the conclusion that many, if not most, of their troubles have been due to bad design in the piping arrangements. Far greater care and better judgment is called for in designing pipe systems for superheated steam than for similar systems using saturated steam, as the strain due to expansion and contraction is greatly increased.

W. E. SNYDER.—The consideration of this subject in the discussions seems to have broadened to include the effect of unequal heating of metal and also the designs of systems of steam piping. These matters are both directly related to the use of cast-iron fittings for superheated steam, as failures may in some cases be due to the improper design of the steam piping; also under some conditions to unequal heating of such irregular castings. As bearing upon the use of cast iron for superheated steam, particularly upon the much discussed question of the possibility of having superheated steam that is in contact with water in the boiler, the following experience may be of interest. A large furnace used for heating slabs for a plate mill was equipped with a small vertical Cahall boiler for the purpose of utilising part of the waste heat. This furnace was fired with under-feed stokers, using forced blast, so that it was possible to obtain a very high temperature both in the furnace and in the boiler, also in the stack. The boiler was set in the usual way for waste heat, *i.e.*, with the large end down. The steam pipe was connected to a flange on the top of the boiler, this connection being made inside the conical-shaped base of the stack which rested on top of the circular boiler setting. This arrangement put a cast-iron elbow on this steam pipe, and about 2 or 3 ft. of pipe on each side of the elbow in the hot gas directly over the upper drum of the boiler. Tests of this furnace and boiler were continued for two weeks, observations being taken every 30 minutes. Frequently the stack temperature would rise to 1,000 and 1,100 degrees F. The thermometer on a Carpenter throttling calorimeter, connected to the steam pipe just outside the stack breeching mentioned above, ranged from 380 to 600 degrees F., depending on the rate of working of the furnace. This variation at times occurred very rapidly, and at the time the thermometer readings were high, the steam escaping from the calorimeter was as completely invisible as though it were natural gas. For twelve hours in succession the average superheat of the steam was 140 degrees, and during the entire time the tests were being made, the superheat of each 12-hour period averaged 120 degrees or over; the steam pressure being about 95 lbs. This boiler has been in operation under conditions similar to the above for at least 15 years. The cast-iron elbow and flange at the top of the boiler, although subjected to such severe service at that described, has never given any trouble. A number of other Cahall boilers using blast-furnace gas, with steam pipe connections made in the same way,

have been in operation for about the same length of time, and no troubles have occurred due to the fittings.

Dr. D. S. Jacobus.—In a large power plant that I have in mind, where the fittings are all of cast iron, and where the superheat averages 150 degrees F., repeated examinations have failed to reveal any deterioration. In other cases, however, where there has been less superheat, and even where a single boiler with superheated steam has been connected into a common main with a number of other boilers furnishing saturated steam, there has been every indication that a small amount of superheat has had an injurious effect. It therefore seems that a difference in the quality of the cast iron may affect the results, and by making a careful study of the matter and knowing the analysis of the cast iron there is a possibility that its action under superheated steam may be predicted.

Prof. H. F. Rugan.—While investigating the phenomenon of the increase in cubic dimensions of cast iron as a result of repeated heatings it became evident that the test pieces deteriorated in strength. I am of the opinion that the influences at work producing such growth at high temperatures are the same that cause the failure of cast-iron fittings at lower temperatures, say, at from 500 degrees F. to 600 degrees F. The effect of the higher temperatures is merely to increase the extent of the changes, producing a maximum growth per heat. Further experiments to determine the length of time required to produce maximum growth developed the fact that a change in the temperature was necessary to produce continued growth. No apparent difference in growth was observed between pieces heated at the same temperature for periods of 3 hours and 17 hours respectively.

[Professor Rugan then proceeded to detail the results of some of his experiments with the growth of cast iron; see Foundry Trade Journal, November, 1909.]

In conclusion, he said: From the experiments I have made there is considerable evidence indicating that grey cast iron subjected to changing temperatures from 450 degrees Fahr., and up, gives evidence of an oxidation of the silicon present, forming silica in a micro-crystal form, which upon cooling causes a disintegration of the surface exposed, ranging generally along the planes formed by the graphite, changing an apparently solid wall into one showing many cracks. It is the constant recurrence of these conditions, produced by the changing temperatures, that, in time not only produces growth, but breaks down the structure of the metal. The experiments conducted by Professor E. F. Miller were so treated, cooling down each night to the temperature of saturated steam. No mention is made of any growth of these specimens. One would expect to find a marked relation between growth and loss of strength. In a comparison between grey iron samples, those subjected to a heating and cooling treatment totalling 1,000 hours would become weaker and larger than those kept constantly at the temperature of superheated steam for a like period. I believe that actual contact with steam is not a necessary condition in this experiment, neither is it a comparative test of the metal, which in service has one surface exposed to atmospheric conditions.

Professor Ira N. Hollis: The discussion of these papers brings out certain interesting and valuable conclusions which cannot fail to assist in the proper use of cast iron for parts of machinery and boilers. Previously existing differences of experience with this metal under a high temperature are shown to be due to fundamental differences of chemical composition or to variations in the temperature. From this point of view, existing data, even though conflicting, can probably be reconciled. The following conclusions as the result of the papers and discussions may be studied with profit in connection with new construction.

(*a*) Cast iron varies in its behaviour under high temperature, starting from about 450 degrees Fahr. In many cases it deteriorates in structure and strength to a marked degree.

(*b*) The effect of high temperature is independent of the medium producing it, whether superheated steam, hot gases or solids.

(*c*) The change of structure or deterioration is much increased by a fluctuating temperature.

Where the temperature is constant, even though as high as 600 or 700 degrees Fahr., the change in cast iron is not serious enough to prohibit its use, but where the temperature varies considerably, the metal is certain to develop cracks and distortion that render it unsuitable for steam pipes and other parts under steam pressure.

(*d*) Cast iron of certain chemical constituents increases materially in volume when subjected to fluctuating temperatures above 500 degrees Fahr.

(*e*) The chemical composition of the cast iron has a material bearing upon the change of shape and volume and upon the development of imperfections.

Certain facts in this connection are well shown by Professor Rugan's experiments. As he states, cast iron containing only combined carbon does not change even under high fluctuating temperatures unless the carbon begins to separate into a graphitic form. Free carbon is one of the factors assisting in the deterioration under high temperature, especially when associated with silicon. The latter seems to be the chief cause of increase in volume. Where the free carbon is constant, the growth in dimensions is roughly proportional to the percentage of silicon.

(*f*) The use of cast-iron fittings for superheated steam is inadvisable where the temperature is likely to fluctuate, but it can be safely used where the temperature is to be constant.

(*g*) Cast-iron fittings should not be placed in any parts of a steam-pipe line where there are serious bending stresses in addition to the stresses produced by internal pressure, unless the combined stresses are fully allowed for, or neutralised by expansion joints.

Open-Hearth Furnace Record.

An excellent record was recently made on the No. 1 open-hearth furnace of the West Penn Steel Company's open-hearth furnace plant constructed at Brackenridge, Pennsylvania, U.S.A. The heats ranged from 82 to 90 gross tons per heat, on a total output of 290 heats, equalling 85½ gross tons per heat, or a total of 28,573 net tons of ingots. The total cost of repairs during this operation was £510. The natural gas consumed by actual meter test was 5,500 cubic feet per ton of ingots produced. During this operation and production of steel, the furnace was off only for a period of four days, and is now producing steel after this short shut down, with practically the same roof and walls of the furnace proper.

Electric Steel Works in Russia.

The first electric steel works in Russia have lately been completed by the Compagnie Electro-Metallurgique de l'Oural. They are situated in the Government of Oufa, near the station at Berdiach, and are intended for the production of special pig-iron, and more particularly high-percentage ferro-chrome and ferro-silicon intended for use in connection with the manufacture of steel for armour plates and projectiles.

Pouring Ladles in the Steel Foundry.

By A. Napier.

The high temperature of molten steel, and the desirability of pouring it in as clean a manner as possible, necessitates particular care in preparing the ladle from which the metal is poured. In the crucible process, of course, the metal is teemed direct from the crucibles as they are taken from the fire, thus obviating the use of an intermediate ladle, unless the molten metal from a number of pots is teemed into a large ladle for pouring a large mould. The pouring of a heat from an open-hearth furnace or from a Bessemer converter, however, involves very different conditions; for, in the first place, the amount to be handled may be anything up to 40 or 50 tons at a time, while, also, a ladle is necessary, since the furnace holding the metal is a stationary affair. Here it is necessary to take the metal—often in large quantities—in suitably prepared vessels or ladles. The size then will vary according to the amount of metal required, but the usual form employed is a ladle constructed of steel plates, lined with special fire bricks 1½ to 2-in. thick, and daubed with ganister. The lining may also be a mixture of loam, sand, and ganister, and the bottom may be rammed ganister; loam or moulding sand alone, have also been employed at times, but the better services is obtained by the use of the fire-brick lining.

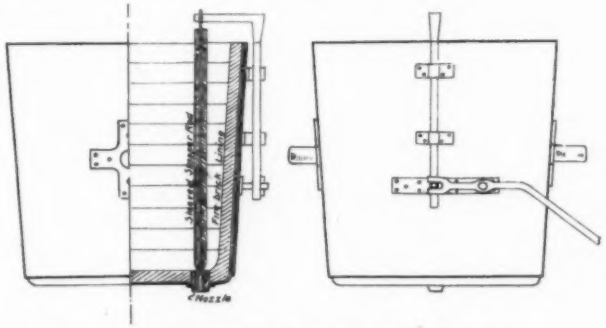


FIG. 1.—HALF-SECTIONAL VIEW AND SIDE VIEW OF LADLE FOR STEEL.

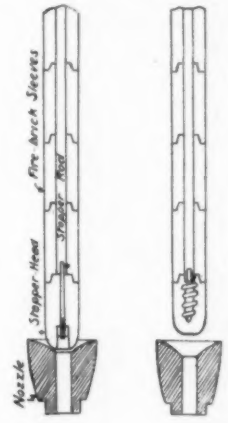


FIG. 2.—ENLARGED DETAILS OF STOPPER ROD AND NOZZLE.

In Bessemer practice the usual method is to sling the ladle on a centre crane, by which it can be carried to the casting pit or to the moulds. In open-hearth practice, however, particularly where only ingots are cast, the ladle is often mounted on a carriage with wheels that can be moved by hand gearing or drawn along by a locomotive or other mechanical means; but in other cases, particularly when facility of handling is desired, similar ladles to those for Bessemer practice are employed, as with these the metal can be more readily transported to any desired point. With the carriage system there is no means of raising the ladle from the ground, and this necessitates running the moulds on rails below the floor level, generally in a pit constructed for the purpose.

With ladles containing large quantities of steel, as those mentioned, pouring by tilting the ladle for the material to run from a lip is not practicable, as the stream would be difficult to properly control, and the skimming of the slag would be very awkward. Instead, the actual pouring operation is done from the bottom of the ladle by means of a nozzle, the outlet of which is controlled by a stopper. There are various mechanisms in vogue for operating the stopper, but the general principle is that shown in Fig. 1 which shows a Bessemer steel ladle. A rod carrying the plug or stopper, and sleeved with a refractory material, is operated by an arrangement of levers from a position convenient to the teemer, who can thus open or close the pouring nozzle. This method allows the stream to be drawn from the clean body of metal, the slag, etc., remaining on the top and not entering the mould. This ensures clean pouring which could not be attained by teeming from the lip of a ladle. Since the iron rod carrying the stopper for the outlet would otherwise come into contact with the hot metal and rapidly suffer, it is encased in a fire-brick sleeve. For convenience this sleeve is made in sections which are threaded on to the rod, each section recessing into the adjoining ones. This arrangement is shown in Fig. 2. The bottom section, which forms the stopper-head, is almost spherical, and fits into the valve seat or nozzle, forming a metal-tight joint. The stopper-head may be fixed on to the rod by means of an iron or steel bolt with a forged head which recesses into the stopper-head, the recess being then filled with stiff fire-clay; or the stopper-head may be moulded to take a coarse screw on the end of the stopper-rod, in place of the bolt. These two methods are shown in Fig. 2. Any similar method may be adopted, provided the metal of the stopper rod is entirely enclosed in the refractory material. Before the stopper-head is fixed on the rod each piece of the apparatus is dipped in clay-wash, as also are the sleeve-sections, prior to being threaded on to the rod. When the rod is enclosed in the sleeve pieces these are held firmly in place by means of an iron collar and cottar-pin. In order to make the joints between

the fire-brick sleeve-pieces perfectly tight, the whole rod is dipped and daubed with clay wash, and is then carefully dried, after which it is ready for fixing into place, attached to the operating contrivance.

The outlet or nozzle is generally placed a few inches from the front side in the bottom of the ladle. Careful adjustment of the stopper-rod, so that the stopper-head will operate freely and also securely close the nozzle when lowered, is very essential; otherwise, a leaky or "running" stopper will result, and metal will be lost, in addition to danger and inconvenience being incurred.

The making of the nozzles and stopper-heads for this work, is, strictly, a clay-worker's job, and one that requires some care and skill, owing to the severe heat conditions that have to be met. The nozzles may be made of almost any high-grade fire-clay prepared to withstand the sudden changes in temperature. For the work in question a mixture of one part by weight of fire-clay to one or two parts "grog" will usually be found satisfactory. The materials are kneaded together with water and allowed to stand to sour thoroughly for a fortnight or more, particularly when the proportion of clay is small. The thorough souring of the mass secures greater freedom from cracks than if the material is made up immediately after being kneaded up in the water. During the souring the clay should be kept in a cool, damp room, and covered with wet cloths. The moulds commonly employed for making the nozzles and stopper-heads are of a close-grained iron, in one piece. When a screw is moulded in the stopper-head, this is formed by means of a hand or similar press. The nozzles are usually made without the use of a press, a two-piece mould being employed. The two halves of the mould are held together by means of an iron ring. The mould is filled tightly, and the clay then bored out with a pointed tool to make the outlet. The stoppers and nozzles are then burned at high temperatures. Many founders look for the pieces to be flashed and flame-stained, but this is only important as indicating that the two pieces have not been ground to fit each other. The objection to this grinding is that it destroys the highly heat-resisting surfaces.

After each teeming the goose-neck with the stopper-head, etc., is removed, and the ladle turned over for cleaning. This turning over is done by turning the ladle on the trunnions shown in Fig. 1. With carriage ladles, particularly, the tilting is best done by means of a hand-operated worm gearing into a worm-wheel keyed on to one of the trunnions. After tilting the ladle and pouring out the slag, which is left in from pouring the metal, any remaining slag is chipped out; the nozzle is carefully cleaned and reformed by ramming a little loam sand round it, coating it with fire-clay wash. After carefully forming and finishing the nozzle, taking care not to leave any loose sand where the stopper-head has to bear, the goose-neck is replaced, and a fresh stopper rod placed in position ready for receiving another heat.

Temperatures of the Electric Steel Furnace.

In a communication to "Metallurgical and Chemical Engineering," Prof. B. Neumann discusses the claims of high temperatures for steel refining in the electric furnace. Temperature measurements made at the Héroult furnace of the Illinois Steel Company, at South Chicago, Ill., U.S.A., were so low as to indicate that the electric steel on the average was not hotter than the steel in a Bessemer converter. He finds the reason for this in the fact that at the South Works Bessemer steel is refined for but one or two hours in the electric furnace, only 200 kw.-hours per ton of steel being supplied, so that the steel is only of good average quality—0.4 C., 0.4 Mn, 0.03 S, and 0.03 P. Prof. Neumann gives details of temperature measurements he made in the case of a Nathusius furnace of 5½ tons capacity at Friedenshütte in Upper Silesia, which were of about the same range as those noted at South Chicago. His statement and comment are as follows:—

"Converter steel was charged into the electric furnace and refined to a very soft steel containing 0.5 to 0.6 C., and very small amounts of sulphur and phosphorus (0.0003 to 0.02 S, and 0.004 to 0.017 P). The treatment lasted for 3½ to 4½ hours, and the energy consumption per ton of steel was 300 to 400 kw.-hours.

"The converter metal when poured into the smaller ladle had still a temperature of 1,450 to 1,470 degrees C When poured from the ladle into the electric furnace the temperature was 1,435 to 1,450 degrees C. The interior of the furnace (immediately after the pouring of the finished steel) had a temperature of 1,535 to 1,560 degrees C., the points of the electrodes, when being withdrawn, being at 1,300 to 1,350 degrees C. The temperature of the electric steel when poured was 1,500 to 1,520 degrees C. for a soft charge and 1,558 degrees C. for a high-silicon charge. In the latter case the temperature when pouring into the ingot was still 1,500 degrees C.

"Since the electric furnace had always to wait a certain time for a charge of fresh Bessemer metal, the interior of the furnace cooled to about 1,000 degrees C. After the metal had been charged into the furnace and the reaction was completed, the temperature of the slag layer was measured and was found to be after an hour, 1,550 degrees C., and after an hour and a-half, 1,600 to 1,650 degrees C. It remained at 1,600 to 1,650 degrees C. until the slag was removed, when its temperature was found to be between 1,500 to 1,560 degrees C. The removal of this first slag and the introduction of the dephosphorising slag caused the bath to cool off somewhat, and the temperature remained in the second period of the treatment a little less than in the first period. These figures prove that an abnormally high temperature is not necessary for the refining process. As a matter of fact, even the heat of the arc for the local heating of the slag is not absolutely necessary, since it is generally known that the Röchling-Rodenhauser furnace permits the same far-reaching refining reactions to be carried out down to traces of sulphur and phosphorus without any arc. The refining possibilities of the electric steel furnace are, therefore, certainly due to a larger extent to the non-oxidising atmosphere than to a very high temperature. There is no doubt that the possibility of producing a higher temperature in the electric furnace helps the refining process considerably, since the higher basic slag can be easily kept fluid, but, as mentioned above, the arc furnace is not absolutely necessary for this purpose. On the other hand, it is quite self-evident that at the places right below the electrodes the temperatures are much higher than the above average temperatures. Calcium carbide, which has often been observed in the arc furnace, begins to form only at about 1,820 degrees C. It does not form in the induction furnace. Further, the electric steel furnace offers the possibility of heating the metallic bath for special purposes to a much higher temperature than is possible in other furnaces."

Fluxes as Applied to the Brass Foundry.*

By Erwin S. Sperry.

In the early days of brassfounding, two things were guarded jealously: the mixtures and the fluxes. Soon the chemist began to make serious inroads into the mixtures, and their secrecy faded away gradually but surely. The mystery of the fluxes was more difficult to eliminate, as, unlike the castings themselves, they did not go beyond the foundry. They could not be analysed without obtaining at least a small quantity, and this was difficult to do, as the brassfounder carefully guarded them and the materials from which they were made. In the course of time, however, the secret fluxes went the way of the brass mixtures so that by the process of evolution "secrets" finally became general technical knowledge. Few brassfounders are now found who claim to have anything original or remarkable in the flux line.

It hardly would be advisable to go into a detailed enumeration of all the fluxes known to mankind, and that can be used in brass melting. Many substances once used for this purpose have now become obsolete, and many others have proved to be valueless. It seems preferable, therefore, to give a description of those fluxes that the test of time has proved valuable, and to explain the manner in which they should be used.

Fluxes for Aluminium.

For years those who melted aluminium used no fluxes at all on it, not even charcoal. It was soon found that this material did more harm than good. On account of the lightness of aluminium, charcoal does not readily free itself, and is apt to become entangled in the metal and produce small, black spots in the casting. It is within the past few years that a flux has been used.

For aluminium, the flux that is most extensively used, and which has proved to be so valuable, is chloride of zinc. It seems to react with aluminium, forming chloride of aluminium and metallic zinc which alloys with the aluminium. When this takes place the dross is changed to a fine, granular condition, which is readily skimmed off. When aluminium is melted, the surface is covered with a rather thick mass, but the chloride of aluminium will change it to a perfectly clear one closely resembling in appearance molten tin or lead. Needless to say such clean metal gives better castings.

The method of using chloride of zinc as a flux in melting aluminium is simple. Small pieces are thrown on the surface after the melting has been completed. Enough has been added when the surface is clear. A very small amount usually suffices, and for 50 lbs. of aluminium a piece the size of a walnut is generally enough. The metal is stirred immediately after the addition, and then skimmed. Those who have not used chloride of zinc should try this excellent material.

Flux for Nickel.

The flux used by makers of nickel anodes has proved a good one. It was first used by A. M. Hill, Newhaven, Conn., one of the first in the United States to make nickel anodes and the inventor of the well-known device for grinding brass-furnace ashes. This flux is not only good, but cheap. It is lime, 3 parts, and fluor-spar, 1 part. The manner of making it is to take the lime and slake it as though mortar were to be made; then stir in the fluor-spar and allow it to become solid. It is then broken up into small pieces for use.

While fluor-spar alone is a good flux, it becomes very fluid when melted, and rapidly attacks a crucible. I have seen a new plumbago crucible ruined in one heat when fluor-spar was used alone. It seemed to soak in and dissolve out the clay from the crucible mixture, and leave nothing but the graphite. The crucible collapsed like an egg-shell when grasped with the tongs. The use of the lime with the fluor-spar is to increase the melting point so that it will not so readily attack the crucible. The proportions previously mentioned have been found satisfactory for nickel. Less lime renders it more fusible. This flux has been found particularly serviceable in melting old anodes, as it dissolves any earthy matter that may be on them. It is used for both new and old material, however, and may be called the standard flux for nickel. The proportions used are about a pint or a good handful for new nickel, and twice this quantity for old material.

It must not be imagined, because the fluor-spar is toned down with lime, that the flux will not act on the crucible, for it certainly will. The crucibles last only five or six heats. In this connection it should be borne in mind that all fluxes act on the crucible to a greater or less extent, otherwise they would not be of value as fluxes.

Fluxes for Copper.

There probably have been more fluxes proposed or used for copper than for any other one metal or its alloys. The fact that copper cannot be melted alone and obtain sound castings from it has brought about this fact. Practically every known chemical has been tried. In the selection of a flux for copper it should be known whether pure copper castings are to be made or whether it is to be alloyed to make brass or bronze.

To make sound copper castings with a flux alone, and without the use of "physic," like silicon-copper, magnesium or similar materials (which, strictly speaking, are not fluxes), is a difficult matter. For this purpose I have found that yellow prussiate of potassium (potassium ferro-cyanide) is excellent. With it sound copper castings can be made, but I do not advise it, as far better results may be obtained by the usual deoxidising agents, such as silicon-copper, magnesium, phosphorus, etc.

Common Salt.

In melting copper for producing brass or bronze, the question is different from the preceding one. For this purpose there is nothing better than common salt. Its value lies in the fact that it possesses the property of reducing any oxide of copper which may form during the melting.

In melting copper for making brass or bronze, about a handful of salt is used, and is preferably put in after it has begun to melt. If introduced with the copper it melts before it, and is apt to volatilise and waste. The action on the crucible is

* Abstract of a Paper read before the American Brass Founders' Association, at the Detroit Convention.

also greater. Too much salt produces a liquid that is apt to penetrate the crucible like fluor-spar, although not as violently or as rapidly. The amount of salt previously given is used for a pot of metal holding about 150 lbs. The quantity need not be exact, as a variation either way does no harm as long as a sufficient quantity is used to do the work.

The theory of the action of the common salt seems to be that at the temperature of the molten copper it breaks up or dissociates into metallic sodium and chlorine gas The latter escapes, and the sodium performs its work in deoxidising.

The flux almost universally and exclusively employed in brass melting is common salt. As previously mentioned, its action is to reduce the oxide of copper formed in melting the copper previous to the addition of the spelter. It is the universal and only flux used in making brass for rolling. It seems to give all that is desired, and has the distinct advantage of being cheap. Any kind of salt will answer and a pure material is unnecessary. The quantity used is about a handful to the crucible. One concern uses one handful while another believes that double this quantity should be used. A good-sized handful, however, seems to be sufficient. It is added after the copper begins to melt, as this appears to be the best time to introduce it. When the right conditions have been produced, there will be a little slag on the top of the brass when it is skimmed.

It is worthy of note that, although every brass rolling mill uses salt in brass melting, few brass-founders who make sand castings employ it. Many of them never heard of its use and others seem to think it is a waste of time. I advocate its use under all conditions.

What has been said about the use of common salt in melting yellow brass, applies equally well to composition or bronze, and it is used in identically the same manner and in the same quantities. It makes no difference whether phosphorus or other deoxidising agents are employed, the salt is used just the same.

Fluxes for German Silver.

German silver is such a refractory material in the rolling mill that much thought has been given the subject of a suitable flux for it. It is a singular fact that the bulk of the German silver manufactured in the United States is made by two concerns. One uses a flux in making it while the other uses none. In justice to the concern which uses no flux at all, I will say that their German silver has a little better reputation, and they have the more particular trade. I cite these examples simply to indicate that fluxes do not by any means constitute the "secret" of making German silver.

The use of the flux by the other concern dates back to 1869, when Frederic Wilcox, a brass caster who was engaged in making German silver, had trouble with black, minute spots in his metal. Tradition states that he gave the matter much thought, and finally believed it was caused by carbon in the metal. More "thought" indicated to him that the only method of removing it was to use a nitrate of some kind which would evolve oxygen and oxidise the carbon. Nitrate of soda, therefore, was used, and upon its use in German silver he obtained a patent (United States Patent No. 96,524, November 2, 1869.) As this material was found to work better with black oxide of manganese, the two afterwards were used together, and now constitute the flux of the aforesaid concern.

Personally, I doubt whether this flux has much value, and the fact that it is possible to make good German silver without it would seem to indicate it. I feel quite sure that there is no oxidation of carbon, as nitrate of soda, when allowed to melt on copper, will not oxidise it; but instead will actually render it sounder. It is also a singular fact, which I have already demonstrated in practice, that a mixture of nitrate of soda or the nitrate of potash (nitre) mixed with black oxide of manganese and used as a flux on copper, will actually introduce metallic manganese into the copper, showing that there is a reducing action. This explains, I believe, the reason for the action of the flux. A slight amount of manganese is introduced.

This is also borne out by the fact that within the last few years, metallic manganese has come into use as a deoxidising agent for German silver and similar nickel alloys. Its use is preferable to introducing manganese through the agency of a flux, as the results are then positive, and certain and predetermined amounts of manganese always can be added. Its use has been attended with excellent results and it seems to be the natural deoxidising agent for nickel and its alloys.

In making German silver, common salt is used in the same manner and with the same results as those obtained in brass and bronze.

The Melting of Washings.

In the melting of washings from the reclaiming of brass-foundry ashes, a flux must be used in the majority of instances unless they have been washed very clean, as is very rarely done. Even with clean washings a flux is advisable. The same rule applies to grindings, skimmings, and similar waste materials. Unless a flux is used when they are melted, a union of the particles of metal is prevented by the presence of so much foreign matter, and instead of fluid metal there usually is obtained a small quantity in the bottom of the crucible and a large mass of pasty material fritted together. When a flux is used the foreign matter is dissolved and clean metal is left.

Plaster of Paris.

For use in melting brass, bronze or composition washings, grindings, skimmings and similar material, I have found nothing better than plaster of Paris. It is a cheap and excellent flux for this purpose. How far back it was employed for this purpose I cannot say, but it was first called to my attention in 1890 by the late C. S. Moore, who can really be called the father of the present scrap-metal industry in the United States.

The value of plaster of Paris as a flux in melting washings, grindings and similar material is that it possesses the property of dissolving what foreign matter may be present in the shape of sand, slag, or oxide, and it has practically no action on the crucible. Furthermore, it is quite cheap. Because it has no action on the crucible, any desired quantity can be used. It melts readily, and forms a thin slag.

To melt washings or grindings with plaster of Paris, mix about 5 lbs. of it with the washings when they are placed in the crucible. Melt in the usual manner. If the slag at the conclusion of the melt is not sufficiently fluid, more should be added. When the metal is completely melted pour the entire contents of the crucible into ingot moulds. *Do not attempt to skim it.* The slag will run into the moulds with the metal and rise to the top. Allow the mass to cool and then dump the ingot moulds. The slag of plaster of Paris can be readily detached by a blow from a hammer, or it falls off under normal conditions. If desired, it may be used again.

It will be found a very satisfactory flux for this purpose.

Action of Plaster of Paris.

Plaster of Paris is calcium sulphate, and when used as a flux the action seems to be one of simple solution. The molten plaster dissolves the foreign matter as sugar is dissolved by water. When coal is present in washings, as it usually is, there is a slight reduction of the sulphate to sulphide, and there will be an odour of sulphur during the melting. This seems to do no harm; I have never been able to find that it injures the metal. In fact, it appears to act in an opposite manner, and any iron that may be present is changed to sulphide and enters the slag. I have always advocated the use of plaster of Paris in melting scrap materials containing iron, and have invariably found it to be followed by good results.

Charcoal.

I have made no previous mention of the use of charcoal, for the reason that it is not properly a flux, although it takes the place of one. I can say without hesitation that charcoal should be used as a covering in melting all the metals previously enumerated. Its value is that in burning it supplies a reducing atmosphere and thus prevents the oxidation of the molten metal. At the same time it covers the metal and prevents the products of combustion from coming in contact with it. It is free from sulphur, which renders it the ideal material for this purpose. It should be coarsely granulated, not powdered, to allow it to cover the metal completely without danger of immediate combustion. Fine coke and coal, though frequently used, are much inferior to charcoal, as they contain more or less sulphur which injures fine grades of metal.

The Influence of Segregation on the Strength of Steel Ingots.*

By F. Wust and H. L. Felser (Aix-la-Chapelle).

The object of this Paper was to determine the degree of segregation of the various foreign bodies encountered in ingot steel and its influence upon strength properties. The material used for the researches was an ingot of basic steel weighing 2,200 lbs., and two small ingots of the same material weighing 5 cwts. There were also used one Siemens-Martin ingot weighing 2,200 lbs., and two smaller ones of the same material weighing 750 lbs. In order to ascertain the distribution of the foreign bodies the large ingots and one each of the smaller ones were cut through longitudinally, one of the halves then being cut up crosswise into 15 and 12 sections. Samples were taken both from the longitudinal and from the crosswise sections, which were tested for carbon, manganese, phosphorus, sulphur, and copper. A small piece was rolled out to a diameter of 30 mm. (1.18 in.), for carrying out mechanical tests; these consisted of tensile and impact tests.

The results, briefly stated, established that segregation of the various foreign bodies is dependent upon the size of the ingot, *i.e.*, in the larger ingots there occurs a less separation than in the smaller ones except as regards sulphur. In the case of steel which rises, segregation takes place to a lesser degree than in that which does not, whence it may be taken that a more complete mixing takes place in the former than in the latter. The average values of about 2,000 determinations are given in the following Tables I. to IV. :—

TABLE I.—*Basic steel ingot. Large ingot. Weight, 2,204 lbs.*

	Average analysis Per cent.		Difference.	
	Outer surface.	Middle.	Absolute.	Per cent.
Carbon ...	0.070	0.0725	0.0025	3.5
Phosphorus	0.054	0.0965	0.0425	78.7
Sulphur ...	0.025	0.0615	0 0365	146.0
Manganese	0.52	0.56	0.04	7.7

TABLE II.—*Basic steel ingot Small ingot. Weight, 5 cwts.*

	Average analysis. Per cent.		Difference.	
	Outer surface.	Middle.	Absolute.	Per cent.
Carbon ...	0.125	0.111	—	—
Phosphorus	0.070	0.075	0.005	7.1
Sulphur ...	0.39	0.043	0.004	10.3
Manganese	0.59	0.52	—	—

TABLE III.—*Siemens-Martin steel ingot. Large ingot. Weight 2,204 lbs.*

	Average analysis Per cent.		Difference.	
	Outer surface.	Middle.	Absolute.	Per cent.
Carbon ...	0.0757	0.081	0 0053	6.8
Phosphorus	0.0525	0.0838	0.0313	59.6
Sulphur ...	0.035	0.0985	0.0655	187.1
Manganese	0.38	0.40	0.002	5 2
Copper ...	0.303	0.377	0.074	24.4

TABLE IV.—*Siemens-Martin steel ingot. Small ingot. Weight, 750 lbs.*

	Average analysis Per cent.		Difference.	
	Outer surface.	Middle.	Absolute.	Per cent.
Carbon ...	0.070	0.085	0.015	21.4
Phosphorus	0 048	0.083	0.035	72.9
Sulphur ...	0.038	0.086	0.048	126.3
Manganese	0.0421	0 0466	0.0045	10.7
Copper ..	0 300	0 373	0 073	24.3

Segregation may be said to have the following influence upon the strength properties :—The results of the static tests are but little influenced. In the notched-bar impact bending tests, however, a marked increase in strength is noticeable as the test piece is taken from portions of the ingot nearer the foot of same. The influence of segregation is more clearly noticeable when the tests are made with very thin test bars, made exclusively from the metal taken from the centre, where segregation has taken place to a greater degree.

* Abstract of a Paper presented before the International Congress of Mining and Metallurgy at Düsseldorf. (Communication from the Metallurgical Department of the Royal Technical University.)

Pillars of the British Foundrymen's Association.

MR. F. J. COOK, last session's President of the Association, comes of a family who have been for several generations connected with the iron trade of the "Black Country." He was born in 1870 at Deepfields, near Wolverhampton, and served his apprenticeship at the Culwell Iron Foundry, Wolverhampton, of Messrs. Joseph Evans & Sons, at the same time studying at the evening classes of the Wolverhampton Free Library and School of Art. Later he entered the service of Messrs. Bellis & Morcom, the well-known engineering firm of Birmingham, and during eight years of work in the drawing office he designed and directed the erection of extensions of the works, and of a completely new factory, including two iron-foundries, brass-foundries, pattern-shops, etc. In 1889 he was appointed to the position of foundry manager, which he still holds.

M. F. J. COOK (PAST PRESIDENT).

In 1907 he was awarded the diploma of the Birmingham Association of Mechanical Engineers, for the best Paper of the Session, on the subject of "The Tensile Testing of Cast Iron." He was one of the founders of the British Foundrymen's Association, and has just completed his second year as President.

MR. R. W. KENYON, President of the Manchester Branch, and Vice-President of the Association, is a managing director of the well-known Accrington firm of ironfounders and machine makers, Messrs. Entwisle & Kenyon, Limited. On leaving school in 1866 at the age of 16 he went directly to that firm, spending a couple of years on the lathe and then being transferred to the pattern bench. In the early days of the firm the business was of a very general nature. Afterwards when the present manufactures were taken in hand, it fell to Mr. Kenyon's lot to introduce machine and plate moulding,

J. E. H. ALLBUT (GENERAL SECRETARY).

R. W. KENYON (VICE-PRESIDENT AND PRESIDENT OF THE LANCASHIRE BRANCH).

MR. H. SHERBURN (HON. SECRETARY OF THE LANCASHIRE BRANCH).

and for many years the foundry was under his special care. The extension of the business removed him from intimate connection with works management, but he always retains an affection for the foundry and all that relates to it.

MR. C. JONES, senior Vice-President of the Association, has been in business at the Ninian Iron & Brass Foundry, East Moors, Cardiff, since 1892. He

MR. W. F. BAGNALL.

is a well-known man in Cardiff, having taken a great interest in the education of foundrymen, particularly the apprentices.

MR. H. SHERBURN, as Hon. Secretary of the local Reception Committee, has borne a large share of the responsibilities for the arrangements for the Convention of the British Foundrymen at Manchester this year. He is the son of Mr. W. H. Sherburn, who is well-known to members as a member of the Council of the Association, and a contributor of papers at the Convention and branch meetings. Mr. H. Sherburn (who is also Hon. Secretary of the Lancashire Branch) studied metallurgy and chemistry at the Manchester School of Technology, and holds the honours certificate for iron and steel manufacture under the City and Guilds of London Institute.

MR. WILLIAM FREDERICK BAGNALL has been a member of the Council of the British Foundrymen's Asso-

G. B. HENDERSON.

ciation since the first convention in Manchester in 1904. He is a partner in the firm of Messrs. Bagnall Brothers, Shalesmoor Foundry, Sheffield, whose chief manufacturing specialities are castings and tools for the crucible steel trade, rolling mill, forge and furnace castings, etc. The concern was established in 1819, and has been in the family between 60 and 70 years, Mr. Bagnall representing the fourth generation engaged in the business. All his life he has been associated with foundry work and practice, both as regards the management of the business and the actual work in the various foundry operations. He is the Secretary of the Sheffield Branch of the Dickens Fellowship, and also well known locally as an amateur musician.

MR. G. B. HENDERSON was born at Sunderland, and served his apprenticeship to the engineering business with Messrs. John Dickenson, of Palmer's Hill Engine Works, Sunderland, serving in all departments, including the drawing office. Afterwards, in order to gain experience, he served at sea as an engineer. From

1888 to 1892 he was assistant engineer under the late Mr. Blechynden for the Naval Construction & Armaments Company, Limited, Barrow-in-Furness, and from 1892 to 1896 was assistant superintendent for Messrs. Cayzer, Irvine & Company, of the Clan Line Steamers, Glasgow. From 1896 to 1900 he was manager of a large engineering business at Montevideo, and is now works' manager for Messrs. John I. Thornycroft & Company, Limited, at their Southampton Works.

Mr. Thomas Swinden studied under Professor Arnold at Sheffield University, and was awarded the Mappin medal and premium for head place among associates; also the City and Guilds bronze metal. In 1905 he was awarded a Bursary by the Commissioners for the 1851 Royal Exhibition for research, and this was followed by the full scholarship, renewed in 1907. In 1908 he graduated as B.Met. at Sheffield. He has read several papers before the Iron and Steel Institute, and was awarded a Carnegie Research Scholarship in 1909.

Mr. Fred Kitson Knowles was born in Halifax, Yorkshire, in 1868 but has lived in Sheffield for the last 37 years. He was educated at first in the Board Schools, then the Central Higher Schools, and joined the Sheffield Technical School as an evening student for the first full session is was open and finally as a day student in 1889. He was appointed Assistant Demonstrator in Metallurgy at the Sheffield Technical School in 1890; Demonstrator with charge of steel making, testing and joint charge of laboratories in 1891; and Lecturer in Fuel and Refractory Materials in 1896. During those years and to the present time he has been associated with Dr. J. O. Arnold, and Professor A. McWilliam, M.Met., A.R.S.M., in many of their important researches. The degree of Bachelor of Metallurgy was conferred on Mr. Knowles by the Council and Senate of the University of Sheffield.

Mr. T. Swinden.

Mr. F. K. Knowles.

Mr. W. H. Hatfield studied metallurgy under Professor Arnold, and became "Mappin" Medallist and Associate of Sheffield University College in 1902. He holds Ordinary Honours prizes and silver medals in the City and Guilds Institute Iron and Steel Manufacture examinations. He commenced his career in the laboratory of Messrs. H. Bessemer & Company, Limited, and is now with Messrs. Crowley & Company as metallurgist and steel works manager.

Mr. W. H. Hatfield.

The Visits of the British Foundrymen's Convention.

The visits which were included in the programme of the Annual Convention of the British Foundrymen's Association, held at Manchester on August 2, 3, and 4 last, were as follows:—

Visits to the Works of Tweedales & Smalley, Limited, Castleton.

The visit on the Wednesday afternoon was to the works of Messrs. Tweedales & Smalley, Limited, Castleton, near Manchester, and was of special interest as giving the visitors an idea of the application of engineering to the great staple industry of Lancashire. The firm commenced business in 1891 as makers of machinery for preparing, spinning, and doubling cotton, and other textile processes. The whole of the power used is electrical. This is generated from two 750- and three 250-h.p. British Westinghouse gas engines, and four 1,000-h.p. Mond gas producers, fitted with sulphate of ammonia recovery plant supplying the gas for these engines. The departments are driven separately from the central power station. The works are lighted by electricity throughout, and cover more than 13 acres, eleven of which are under roof; and the firm has its own railway siding. About 2,000 men in all are employed. The whole plant is equipped with labour-saving appliances, and the production of each class of work is conducted on the most economical principles.

BRITISH FOUNDRYMEN ENTERTAINED TO TEA BY MESSRS. TWEEDALES & SMALLEY, LTD., CASTLETON.

The visitors were particularly interested in the equipment and layout of the foundry, in which repetition work may well be said to have been reduced to a fine art, and where upwards of 300 men are employed. The foundry is bounded along the one end by a bank which carries the main line to York, of the Lancashire and Yorkshire Railway. The best possible use has been made of the natural advantage of the position, the cupolas being so arranged that the charging platform, which runs the full width of the foundry, is on a level with the trucks delivering the material. A siding has been laid on from the main line, the centre of the permanent way of which is covered with a number of grids through which sand and other foundry requisites are discharged direct from the trucks into the brick hoppers on the foundry level, thus reducing to a minimum the amount of manual labour required to handle material.

There are four cupolas which, as already stated, have their charging doors on a level with the trucks of material. The internal diameters of the cupolas range from 2 ft. 9 in. to 3 ft. 6 in., and they each have an approximate melting capacity of 5 tons per hour. The material is loaded from the trucks into bogies, weighed on a platform-weighing machine, which occupies a central position, and charged direct into the furnace. Scrap from the works and foundry is elevated to the charging platform by two electric hoists, each with a lifting capacity of 30 cwts. The mouths of the cupolas are inclined inwards at their tops, and each pair exhausts against a central baffle wall in a brick chamber, which arrangement not only tends to eliminate the risk of fire from sparks, but also serves to intercept the greater portion of the dust and so reduce gutter cleaning to a minimum. The dust collected in the chamber is passed down a shoot direct into the foundry. Blast is supplied by motor-driven Roots blowers, a separate unit for each cupola. These are housed in pairs in brick buildings on the foundry floor, and each blower is driven from a counter-shaft which in turn receives motion by belt from a 24-h.p. Westinghouse motor.

The foundry occupies two bays 202 ft. and 50 ft. respectively, by 408 ft. long. The first-mentioned is covered by a saw-tooth roof with north lighting, and is 23 ft. high to the eaves; the last-named is covered by a single-span 23 ft. high to the crane runways, this bay, the floor of which is served by a 10-ton, 3-motor crane, by Craven Bros., being devoted to cylinder casting and loose patterns. A portion of this floor is devoted to cylinder casting (for carding engines) and is laid with chequered plates and provided with three pits. Here cylinders are cast up to 50 in. in diameter. The cylinder moulds are dried in the cast-iron boxes, and on an average five casts are made at each moulding. Adjacent to the pits referred to are two gas-fired core-drying stoves each 16 ft. square. With the exception of these cylinders the whole of the castings are made in green sand.

The small-work bay is provided with a pit for casting cone drums and calender rollers. Formerly, there

was considerable difficulty experienced in getting these last straight but the trouble has been entirely overcome by the adoption, in a modified form, of pipe casting. The boxes of cast iron, perforated with a number of holes throughout their length, are secured to the sides of the pit. A rod is then introduced, the lower end of which is sweated up to the size of roller desired and pointed at its end to ensure centreing; the sand is rammed by hand until the former is covered, and the box is then filled up loosely. A collar and cap are next placed over the top end of the rod and the cap secured to the box head. The rod, together with the former and collar are then drawn out by means of an electric crane, the cap removed, the core inserted, centred in the hole left by the pointed end of the former, and the mould is ready for the metal. The crane which serves this pit was constructed in the Company's shops. All motions are operated from a single motor, through friction clutches. The slight resistance of the clutch, which has to be put partially over for lowering, is overcome by suspending a weight above the shackle hook. This hook is hung dead central tranverse the moulding box and centralisation in the travel direction is readily accomplished.

tested on wheels to ensure perfect truth. From each cupola a main line of rails, 20-in. gauge, runs for the full length of the foundry, turntables being provided at frequent intervals of its length, leading off to branch lines which completely serve the floor. The metal is tapped into ladles, of which there are four to each cupola, holding from 7 to 8 cwts., and carried upon bogies upon the track, by means of which the metal is conveyed to within a few feet of where it is required. The floor is further served by some 20 manual cranes, of the Company's manufacture. These deal with loads up to one ton, and are carried on runways, about 30-in. centres, suspended from the roof principals. There are two edge-runner mills, one for the cylinder bay and one for the small work bay. These, together with the sifters, are placed adjacent to the sand bunkers previously referred to.

Adjoining the cylinder-casting bay is the pattern stores and pattern filing-up shop. Iron patterns are almost exclusively used; the master wood and other special patterns are ranged in racks on the floor above. The cleaning shop and the casting stores occupy a similar position with regard to the larger bay. The equipment of the first-named includes numerous cylinder machines, a Tilghman sand-blast machine and

General View of the Works of Messrs. Tweedales & Smalley, Ltd.

At the present time the card sides are moulded entirely by hand. A recent introduction will, however, dispense with hand-moulding.

For banding the boxes the Company have constructed an electric crane of two tons capacity, which travels on runways 18 ft. centres, the full width of the bay. This is of the two-motor type, and is provided with two winding drums which are operated in parallel from a common shaft and worm gear. The lower ends of the ropes are connected to a cross bar and lifting shackle to ensure a constant vertical lift. The portion of the foundry for casting ring frame ends is served by a pneumatic air hoist, capable of lifting 10 cwts.

Amongst the usual foundry auxiliaries is a hydraulic core-making machine, by the London Emery Works Company, and hard by is a core-drying stove 8 ft. 6 in. by 7 ft. by 6 ft. This latter is fitted with four drawers and fired with producer gas through Bunsen burners. The cores produced on the hydraulic machine are a two-chamber hose sand-blast, this last is furnished with an exhausting fan which delivers the sand into bogies, to be afterwards used in the foundry for parting. The drive for the machines in this shop, is from line shafting installed below the floor, the shaft being belt-driven by motor. The casting stores are in charge of a clerk who records the weight of all castings passed in or drawn out. The small air-compressor and hydraulic machines which are installed in this shop are motor-driven; in fact, with the trifling exceptions referred to, the foundry and auxiliary plant is electrically operated throughout, and is, as are also the whole works, electrically lighted.

It is interesting to note that in addition to sulphate the Company now recover the crude oil from their producer gas, this last being used in the oil-fired furnace. There is a well-equipped laboratory in which analysis is made and records kept of all raw material, as also physical test on samples.

VIEW IN CYLINDER BAY, SHOWING LOOSE PATTERNS IN THE FOREGROUND, AND CUPOLA IN ARCHWAY ON RIGHT OF CORE-DRYING STOVES; WORKS OF TWEEDALES & SMALLEY, LTD., CASTLETON.

BAY FOR SMALL WORK (LOOKING TOWARDS CUPOLAS); WORKS OF TWEEDALES & SMALLEY, LTD., CASTLETON.

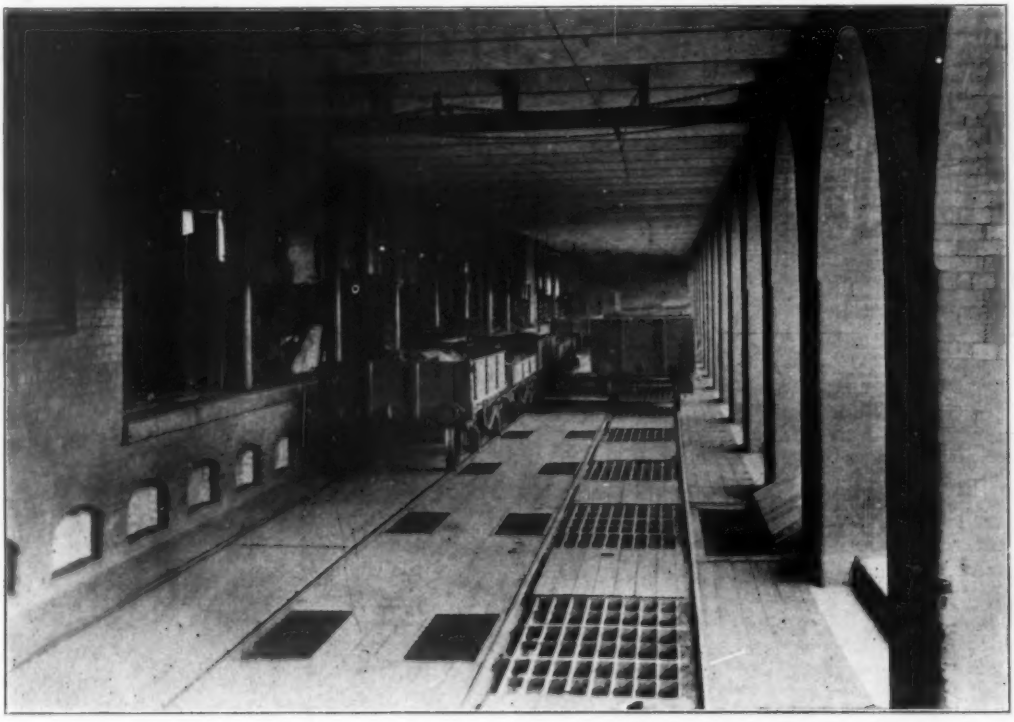
Locomotive Works of the Lancashire and Yorkshire Railway.

Tuesday afternoon was spent in a visit to the locomotive works of the Lancashire and Yorkshire Railway, at Horwich. These works were established in 1886 for the purpose of repairing and renewing the locomotive stock and for the railway engineering work. They are situated near Black Rod Station, the workshops occupying 22 acres. Included in these shops are a forge, steel foundry, iron and railroad chair foundry, brass foundry, and various engineering shops. The tramway lines throughout the works communicating with the various shops cover 7½ miles, and on these the material is drawn by very small locomotives. The largest buildings are the boiler shops 440 ft. long, and the forge, 452 ft. long. The latter building is equipped with Siemens regenerative furnaces for reheating, the doors of which are pneumatically raised, a 14-in. merchant mill, and an 8½-in. guide mill, together with a tyre mill, and a 30-in. cogging mill, with electrically-driven live rolls. There are also a 35-ton duplex hammer, an 8-ton and a 25-ton hammer. Eighteen gas producers of Wilson's type supply gas to all the forge furnaces.

The foundries are particularly well equipped departments. The steel foundry, a shop 150 ft. long by 135 ft. wide, is fitted with Siemens-Martin regenerative melting furnaces, having a high-level tramway for carrying the ladle, and a narrow gauge tramway beneath for mould trolleys; and also core-drying furnaces, moulding machines, etc. All the furnaces of the steel foundry are heated by gas. The Tropenas process is employed for making steel castings.

A still larger department is the iron foundry, 212 ft. long by 111 ft. wide. Hydraulic power is employed for working certain cranes, but there are in addition overhead electrically-driven travelling cranes which can be used in both the steam and iron foundries. Owing to the land at the rail level being considerably higher than the foundry, it is possible to unload the coke and iron directly from the trucks to the charge holes of the cupolas or melting furnaces. Similarly, the gas producers for the furnace are charged at the top, while the ashes are deposited into tram wagons running on the lower level. The same arrangement applies to the chair and plate foundry, a shop 124 ft. long by 128 ft. wide, in which the two cupolas are charged from the high level. Hydraulic power is employed for the charging.

The brass foundry is 164 ft. long by 47 ft. wide. Gas is employed for melting heavy work, while the crucible furnaces are coke-fired. There is a special core-drying stove, heated with waste gases from crucible furnaces.



CUPOLA-CHARGING PLATFORM; WORKS OF MESSRS. TWEEDALES & SMALLEY, LTD., CASTLETON.

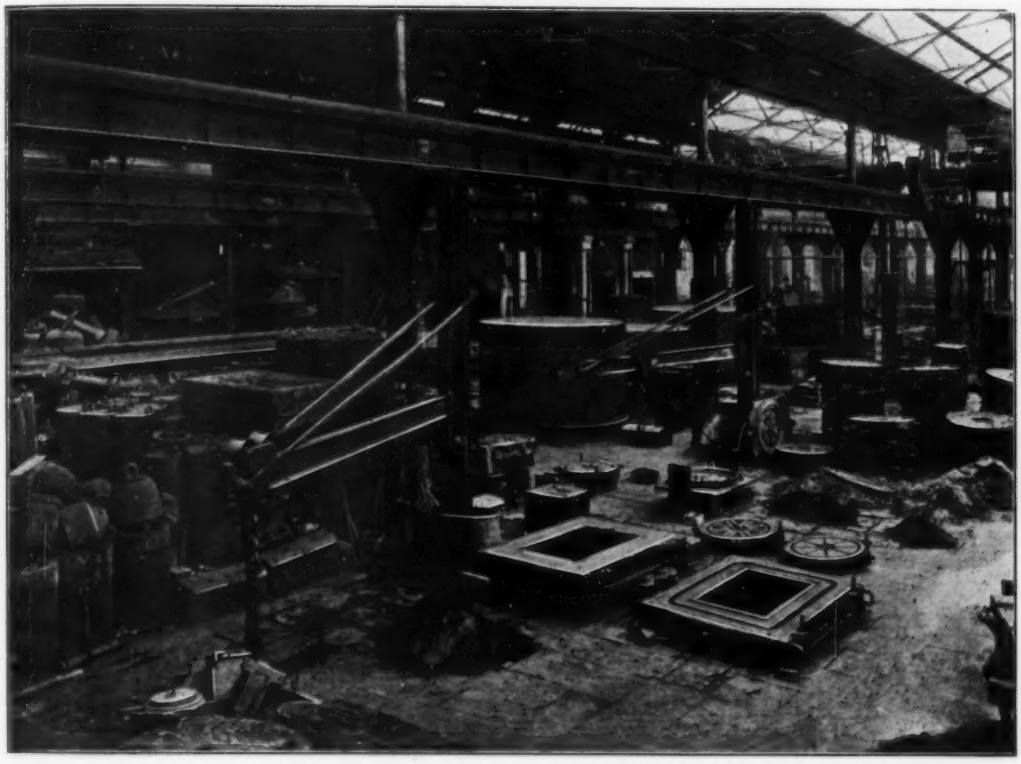
Electric power for the works is obtained from a central power station, in which electricity is generated by two 300-kw. Belliss & Morcom high-speed engines and dynamos. A feature of this station is a barometric condenser utilising the steam from several other engines of large capacity.

The largest shop is the erecting shop, which is 1,520 ft. long and 118 ft. wide. In this shop there are no fewer than 20 30-ton electrically-driven overhead travelling cranes, and a large quantity of other powerful machinery. In the dining rooms accommodation is provided for 1,100 men, whose meals are cooked or heated by attendants. In connection with the Mechanics' Institute and Technical School, every provision is made for the education and recreation of the workpeople.

It may be added that the works have been very successful in the production of steel castings, of which

they have considerably more than 100,000 in use. The foundry has been able to furnish material which it is claimed has been found sound, homogeneous, free from internal strains, of the requisite tensile strength and ductility, and equal to steel or iron forgings. These castings have stood a minimum test of 26 tons per square inch. The Company have been very successful with their gear wheels and similar castings. Of these, 250 were running on the Liverpool and Southport Railway motor cars a short time ago, and in six years, out of 21 which had to be renewed, only three were renewed through wear and tear. They have run 48,500 miles per annum. The following chemical analysis of these steels has been kindly furnished to us:—Carbon, 0.27 to 0.29 per cent.; silicon, 0.10 to 0.20 per cent.; sulphur, 0.05 to 0.07 per cent.; phosphorus, 0.05 to 0.06 per cent.; manganese, 0.8 to 1.0 per cent. In these works a special point is made of scientific annealing, using the thermo-electric and the Féry pyrometers in conjunction with the thread recorder. The result of the system carried out under the management of Mr. George Hughes has been in every way excellent.

Locomotive Works of the Lancashire and Yorkshire Railway, Horwich.



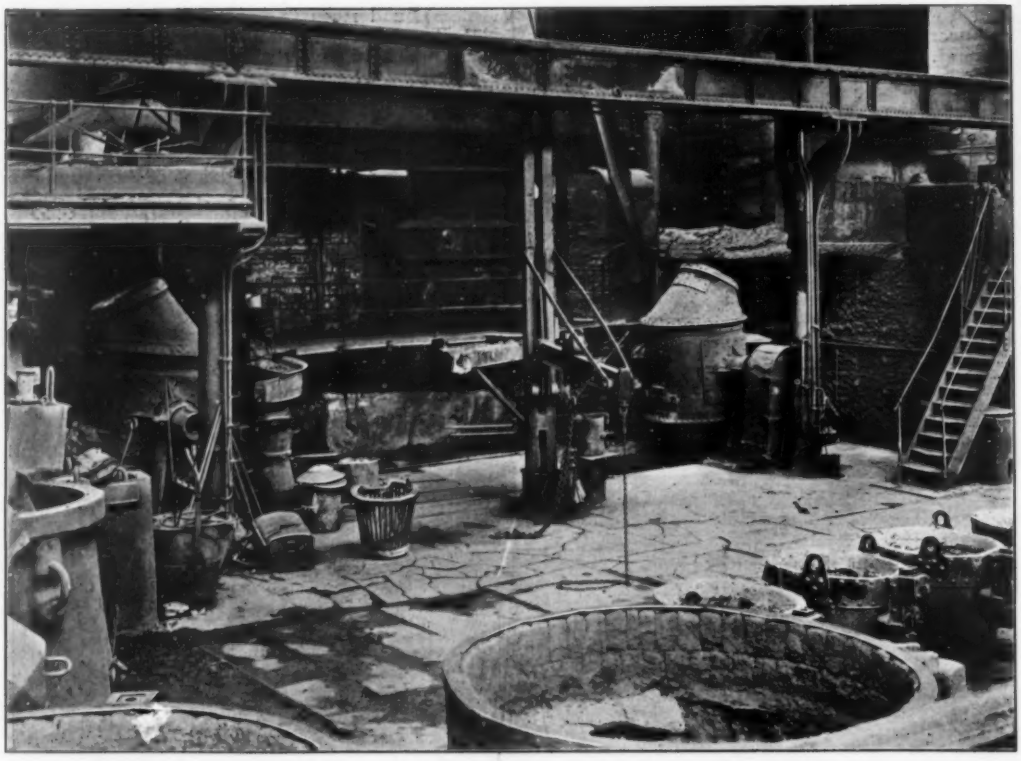
General View in Steel Foundry; Lancashire and Yorkshire Railway Works.

Visit to Chester and Eaton Hall.

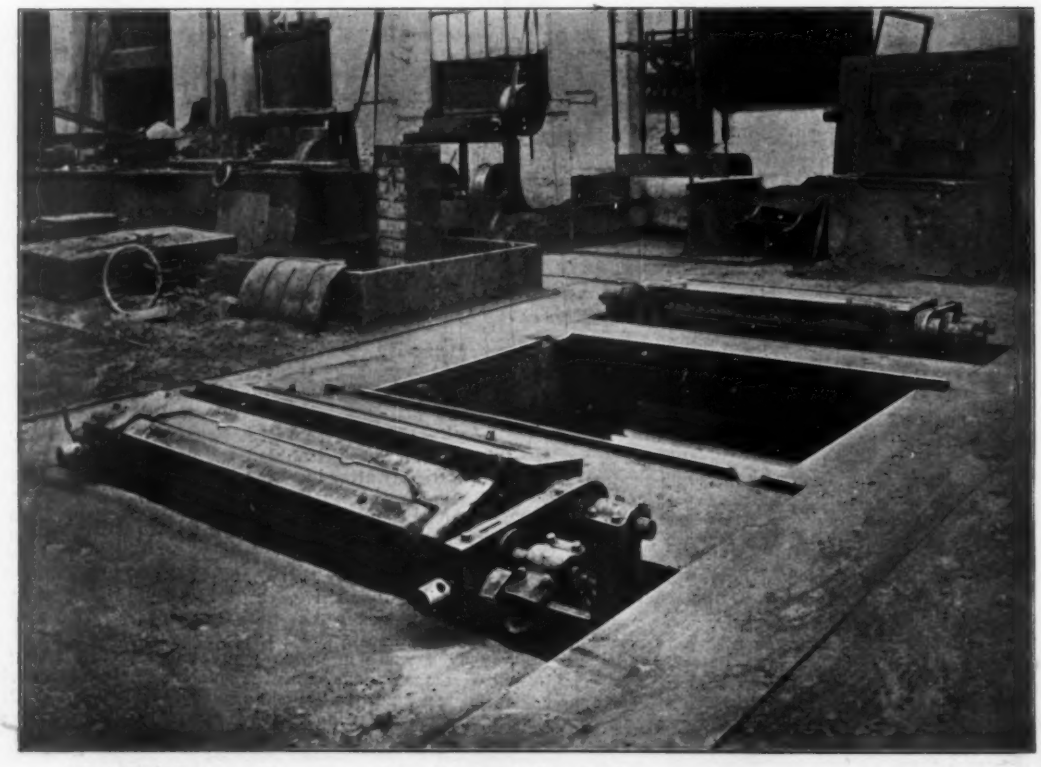
The third day of the Convention, as is customary, was devoted to a pleasure excursion. Leaving the Manchester Exchange Station at a quarter to eleven, the party reached Chester at noon. Lunch was served at the "Old Bear and Billet" Hotel. Before and after the drive into the surrounding country, the visitors found much to interest them in the famous old city. For antiquarian interest there are few places which surpass Chester. The walls, which still completely surround the city, are to a large extent remains of the original Roman fortifications, and a very pleasant and instructive promenade can be made upon them. Among the features of the ramparts is King Charles's, or the Phœnix Tower, from which Charles I. watched the final defeat of his army in the war with the Parliament. The town itself is full of old-world interest, Its "Rows," covered shopping promenades in two storeys, date from mediæval times, and there are many other fine specimens of the half-timbered style of architecture, while still farther back can be dated the Cathedral, the remains of the original Castle, and the remains of the Roman Bath—to mention only a few of the attractions which survive for the lover of the ancient and the picturesque.

Immediately after luncheon the party drove to Eaton Hall, about three miles from Chester, to view the palatial residence of the Duke of Westminster. This magnificent pile, the fourth building on this site, was commenced in 1867, and was designed by the famous British architect, A. Waterhouse, R.A.

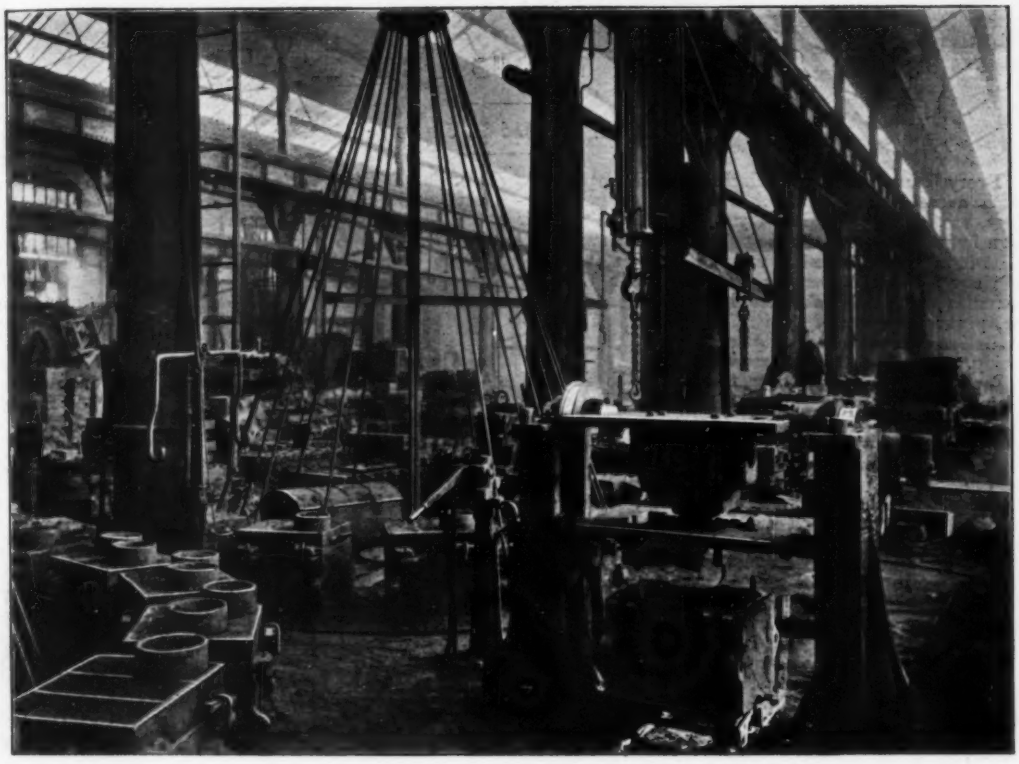
Resuming their drive, the party visited Hawarden Castle, well-known as the residence of the late Mr. W. E. Gladstone. The return journey to Chester was by a route affording many fine and interesting views, among them being the ruins of Beeston Castle, a Norman stronghold said to have been built in 1220 and destroyed during the Parliamentary Civil War.



TROPENAS PLANT IN THE STEEL FOUNDRY; LANCASHIRE AND YORKSHIRE RAILWAY WORKS.



FIRE-BAR CASTING MACHINE IN IRON FOUNDRY; LANCASHIRE AND YORKSHIRE RAILWAY WORKS.



VIEW IN IRON FOUNDRY, SHOWING AXLE-BOX MOULDING MACHINE WITH TURN-TABLE, &C. ; LANCASHIRE AND YORKSHIRE RAILWAY WORKS.

CENTRE BAY OF IRON FOUNDRY ; LANCASHIRE AND YORKSHIRE RAILWAY WORKS.

The Selling of Brass Foundry Refuse.*

By Jesse L. Jones.

Every brass foundry produces certain by-products such as ashes, tailings, skimmings, grindings, turnings, etc. Some foundries try to use certain of their own by-products, but the majority of them have found that it is more economical to sell all such material to the scrap dealer or smelter, for the reason that few manufacturing establishments, however large they may be, produce enough of such refuse to warrant the installation of a complete equipment for smelting and refining.

Broadly speaking, scrap material may be disposed of in two ways. It may be sold to the scrap metal dealer or it may be shipped to the smelter.

All low-grade material must of necessity ultimately find its way to the smelter. High-grade material, such as copper turnings, red brass turnings, yellow brass turnings, miscellaneous scrap castings, etc., can usually be run down in crucible furnaces and disposed of advantageously in the ingot form, hence it may never reach the smelter.

Every scrap dealer is a law unto himself in the matter of sampling and judging scrap material and every brass foundry is a law unto itself in its manner of grading its waste products. The scrap dealer has to learn the eccentricities of each separate foundry and this information may cost him dearly. As there are no recognised standards of quality for brass ashes, tailings, skimmings, etc., many purchasing agents make persistent efforts to sell refuse that is absolutely worthless. This misguided zeal of sellers and the tendency of the scrap dealers to generalise and judge one foundry by another, leads to frequent misunderstandings and controversies, and sometimes an occasional scrap dealer will attempt to safeguard himself in ways that are more ingenious than honest.

The majority of scrap dealers, however, are honest and reliable, and when the limitations imposed upon them by competitive bidding are taken into consideration, commercial dealings with them are, as a rule, satisfactory, and there are certain advantages to be noted in dealing with them. The small dealer is generally near-by the foundry, and his freight charges are thus eliminated or very low, so that he can make a close bid, while at the same time if he calls for the material with a wagon it does not have to be boxed or barrelled. Further, he always expects to pay cash, and this fact of getting ready money carries a lot of weight with the average purchasing agent.

By a smelter is meant a firm that has a complete equipment of water-jacketed copper smelting furnaces, cupolas, reverberatory refining furnaces and whatever else is necessary for the handling of all kinds of low-grade and high-grade material. The number of these firms is constantly increasing and the advantages of disposing of brass foundry refuse to them are many and the disadvantages are few. The smelter takes all classes of copper-bearing scrap, and pays for it according to its copper content as determined by sampling and assay. The material may be sampled by the seller before shipping if desired. This need not be done, however, as when the scrap is received by the smelter it is sampled in the customary manner used for ores and three samples taken, one being turned over to the seller's representative, one taken by the smelter and one sealed and kept as a referee sample. The seller's representative also checks up the weight of the shipment as it is unloaded, and he sees that a fair sample is taken in the case of material like long copper turnings mixed with steel turnings, which cannot be sampled by quartering, but has to be sampled by selection.

The buyer's and seller's assays should agree very closely, and settlement is made on the split assay, after deducting the smelting charge and freight, plus a nominal deduction of 1.3 per cent. of the copper content. The price used in each transaction is that current for casting copper. For high-grade material there is no smelting charge.

In the illustration is shown a curve which gives the minimum assay that a low-grade copper-bearing material must contain to warrant shipping it. It holds good for material containing not over 10 per cent. of copper. This curve is based on a maximum smelting charge, a rather high freight charge, and a high deduction from the market price of copper. The curve shows at a glance the points, dependent

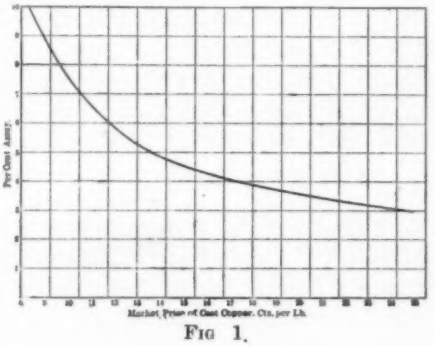


FIG 1.

on the selling price of copper, where it ceases to pay to ship brass foundry refuse. When it is not profitable to ship such material it may be stored until such time as an advance in the price of copper will warrant its sale.

The above outlined plan is a much more satisfactory and legitimate method of arriving at the market value of scrap than the competitive bidding plan. The seller is sure to receive all that his material is worth, and the buyer knows that he will make a fair profit, so that there is no unusual incentive for either party to resort to any sharp practices. The methods used by the smelters are accepted without question in the sale of ores of copper, lead, zinc, etc., and when better understood will be accepted just as readily by the brass foundries. One of the valuable features of selling by assay is that it emphasises the importance of careful grading of all scrap material and not allowing low-grade material to be mixed with high-grade material. Much of the profit of the small scrap dealer comes from buying miscellaneous lots of scrap that are composed partly of high-grade and partly of low-grade material at a price that approximates the value of the low-grade material. He then carefully grades the material that he has bought and thus realises a fair profit.

In selling on an assay basis the importance of keeping cores and heap sand apart from the skim-

* Abstract of a Paper read before the American Brass Founders' Association, at the Detroit Convention.

mings and other material that is washed, is obvious. By so doing, tailings may often be stepped up from 3 or 4 per cent. of copper to 12 to 14 per cent. of copper. By drying the tailings (which may contain as high as 20 per cent. of water), and then storing them under cover their value is further increased. If you ship a 60,000-lb. car of tailings which runs 20 per cent. of moisture, you will pay freight on six tons of water, and if the material dries out *en route* to its destination you may be suspected of shipping short weight.

As a rule, the holding of scrap material until a high market is reached is not advisable. The increased freight charges for small lots justifies waiting until a minimum carload is obtained, but further holding of it is not warranted. The brass-founder is not in the scrap metal business, and if he loses at one time by selling at stated intervals, he will gain at another, and find that it evens up in the long run.

In conclusion, we may say that every brass-founder will find it to his advantage to get in touch with one or more reliable smelters, and become familiar with their methods of doing business on an assay basis. He should also have a competent metallurgical chemist examine his by-products and report on their average copper content and market value.

Effects of Carbon, Sulphur and Silicon on Commercial Cast-Iron.

The 80th annual meeting of the British Association for the Advancement of Science was opened on Wednesday, August 31, in Sheffield, under the presidency of the Rev. Professor T. G. Bonney.

In the Chemical Section MR. J. E. STEAD dealt in his Presidential address with the effects of carbon, sulphur and silicon on cast-iron, his conclusions being as follows:—

(1) The experimental results advanced show proof that carbide of iron in presence of iron sulphide crystallises with a minute quantity of sulphur not exceeding about one-thousandth part of the weight of the carbide, but the nature of the iron-carbon-sulphur compound has not yet been determined.

(2) It seems almost, if not absolutely, certain that it is the sulphur crystallised with the carbide which makes the latter stable.

(3) The evidence appears to support the view, long held by some and more recently accepted by others, that during the freezing of iron-carbon-hypo-eutectic alloys after the crystallisation of the primary austenite, and in the eutectic and hypereutectic alloys, it is the carbide and not graphite which primarily forms and that the carbide afterwards decomposes into graphite and austenite.

(4) It has been proved by chemical methods that when the hypo-eutectic alloys, low in silicon, freeze, nearly all the silicon crystallises out with the primary austenite; and it follows that on gradually increasing the carbon so as to reduce the quantity of primary austenite, the silicon remaining constant, the austenite which does form must be as gradually enriched in silicon up to saturation point; and, when that point is reached, the excess silicon crystallises out with a portion of the carbide of iron to form carbo-silicide of iron. Other elements remaining constant, the same result must follow on gradually increasing the silicon.

(5) In the alloys of eutectic proportion and in the hypereutectic alloys, as no primary austenite can form, the silicon crystallises primarily with the carbide.

(6) In Cleveland pig-iron containing about 1.5 per cent. phosphorus, a ternary eutectic of iron-carbon-phosphorus takes the place of the iron-iron-carbide eutectic. In white irons containing 3 per cent. carbon and under 2 per cent. silicon, after the primary austenite has fallen out of solution carrying practically all the silicon, it is not iron-iron-carbide which forms, but independent plates of cementite, or carbide of iron, and after these have crystallised and the residual mother liquor has arrived at the composition of the ternary iron-carbon-phosphorus eutectic, the latter solidifies at 945 degrees C.

(7) In Cleveland irons which become grey on cooling, and in which there is no primary austenite, the same iron-carbon-phosphorus eutectic is the only eutectic to form during cooling, and, instead of a ternary iron-carbon-silicon eutectic, two independent cementites crystallise—one a silico-carbide, and the other carbide of iron possibly containing a little silicide in solid solution. The micro-examination of the cold alloys, to which a little sulphur had previously been added when the metals were melted, led to the conclusion that it is the carbo-silico-cementite which primarily crystallises.

(8) There is evidence that the primary carbo-silicides are exceedingly unstable and are the first to decompose into graphite and silico-austenite.

(9) In the absence of any sensible quantity of phosphorus, two cementites form—one the silico-carbide cementite, the other the carbide cementite—and these crystallise together as a eutectic mixture.

(10) The exact composition of the two cementites has not yet been determined, as no chemical method has been found for their isolation.

(11) It is evident that it is the exceedingly unstable character of the silico-carbides which is responsible for the greyness of commercial metals rich in silicon and low in sulphur.

(12) Silicide of iron, when heated at 1,000 degrees C. with pure white iron free from silicon, effects the decomposition of the carbide of the white iron. Based on this observation the hypothesis seems justifiable, in cases where all the silicon present in hypo-eutectic alloys crystallises out with the primary austenite, that after the carbide has solidified diffusion of the silicide follows, and this leads to the decomposition of the carbide of iron into graphite of iron.

(13) Many of the results arrived at by chemical analysis support the hypothetical conclusions of Gontermann, who depended mainly on data obtained by thermal methods of treatment.

Manufacture of Carbon-Electrodes in Sweden.

At a meeting held recently at Helsingborg, in Sweden, Mr. Gôsta Forssell, engineer, of the Höganees-Billesholm Iron Works, exhibited some samples of carbon-electrodes for electrical furnaces, which had been made at the Höganees Works since 1907, and which have already obtained a large sale in Sweden and for export. One of the electrodes exhibited measured 80 in. in length and 13 in. square. These electrodes have been adopted by a Norwegian works where they are used in bundles, each bundle consisting of 12 electrodes. The manufacturers, however, intend within a short time to increase the dimensions, with which object in view they have ordered an electrode press, which probably as regards size will beat all existing records. The material from which the electrodes are manufactured, is composed of a mixture of graphite, anthracite and petroleum coke with tar. The whole of the raw material, apart from the tar, is imported from abroad. At the same time were shown samples of iron sponge, which forms a raw material for the manufacture of open-hearth steel, and which is treated in special furnaces at the Höganees Works by means of inferior Swedish coal. The inventor of the process is Mr. S. E. Sieurin, and the raw material is partly used for certain chemical industries as well.

Foundry Plant and Equipment.

A Portable Combination Woodworker.

The accompanying illustrations show a wood-working machine which combines a cut-off saw, rip-saw, dado-head, moulder, jig-saw, jointer, sander, boring machine, and emery wheels, all operating on one shaft, except the jig-saw, which is driven by an eccentric, belted from the mandril. As will be seen, the machine is driven by its own mechanism—a 5 h.p. verticle 4-cycle engine, which may be either water or air-cooled, the air-cooled being recommended for portable use.

As regards the cutting mechanism, the changes may be made from one attachment to another in one minute, or less. The main table top, 29 in. by 40½ in. by 1⅛ in. thick, raise and lowers at each corner simultaneously by an adjusting wheel at the front of the machine. Rip and adjustable cross-guides are fitted,

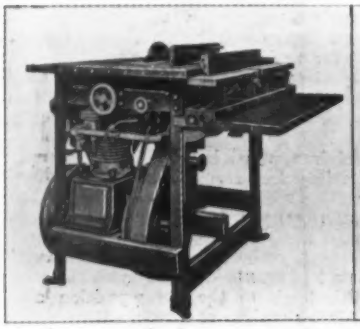


FIG. 1.—RIP SAW AND JOINTER.

FIG. 2.—JIG SAW AND BORING ATTACHMENT.

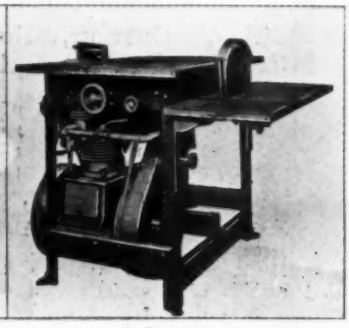


FIG. 3.—DADO-HEAD AND SANDER.

PORTABLE COMBINATION WOODWORKER.

and the table top can be locked to any desired level. The jointer table top is 16 in. by 40½ in. by 1⅛ in. thick. This top is also used in connection with the sander and the boring attachment, and is adjustable to any desired height. The jointer top can be raised to the level of the main top, giving an operating table of 43 in. by 40½ in. Both tops are made from maple strips, glued together. The mandril on which the cutters turn, is of cold-rolled steel, 1 $\frac{3}{16}$ in. diameter, with a speed of 4,000 revolutions per minute.

The corners of the framework are of heavy angle iron, and the horizontal pieces of straight-grained oak, bolted together. The side table is fitted with guides over which operates a slide carrier for use in boring only. Every size of rip and cut-off saws up to 14 in. can be used. For plowing and grooving, the dado-head will take from in. to 2 in. wide at one cut. The jig-saw has a speed of 3,600 in. per minute in cutting stroke, and handles work up to 5½ in. thick. The sander is a 10-in. flat disk, with adjustable sander guides with shield. The same end of the mandril used for the jointer ar sander, has a ½in. reamed hole for machine bits.

The makers of this apparatus are Messrs. Diffin & Smith Company, 606, Quarry Street, Philadelphia, Pa., U.S.A.

A Tilting Fore-hearth for the Cupola.*

The tapping of the cupola, particularly in the simple designs where no fore-hearth is employed, is the most dangerous of the furnace operations. In the accompanying illustrations is shown a tilting fore-hearth which, it is claimed, entirely obviates the danger associated with the old method of tapping. The squirting out of the iron, and the stopping of the tap-hole is confined and controlled by the apparatus shown, in the following manner.

The fore-hearth consists of a refractory-lined receptacle mounted on trunnions, the axis of revolution running directly against the furnace. The trunnion abutting into the cupola is tubular and is continued through the furnace wall, forming a passage for the metal out of the cupola. The fore-hearth is prepared in the same way as the old fixed fore-hearth, but is arranged to be tilted by means of a gear-wheel and worm-gear. As the simple tapping of the metal through the runner which lies in the trunnion into the tipping fore-hearth would not prevent the slag pouring with the metal, the fore-hearth is constructed to deal with this. A second and smaller chamber is joined to the fore-hearth, as shown in the illustration, and this represents the real container from which the metal is poured into the moulds, being only connected with the first part of the fore-hearth by a connecting channel or opening at a point near the bottom. The fore-hearth is first tilted back, and when a certain amount of metal (with any accompanying slag) has entered the fore-hearth from the cupola, the former is tilted forward so that the connecting channel between the two chambers is covered, and only the clean iron can enter the pouring chamber, the slag being retained in the rear part of the fore-hearth by means of the dividing partition. Afterwards, regardless of the quantity of metal or slag in the fore-hearth, only the clean metal at the bottom is drawn off to the pouring chamber. Pouring is done by tilting the fore-hearth as shown, easy regulation of the flow of metal being secured. The fore-hearth is lined with fire-bricks,

* Abstract translated from "Giesserei Zeitung."

while the pouring chamber, which must be relined about every 10 heats, is rammed up with sand. This is easily accomplished by setting a large tube, the size of the internal diameter of the finished chamber, in the casing of that chamber, and then ramming sand hard round it.

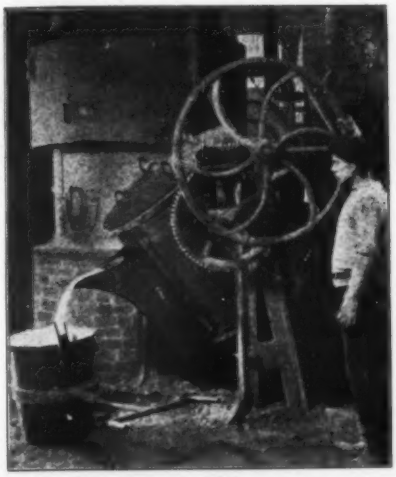


FIG. 1.—SIDE VIEW OF TILTING FORE-HEARTH.

FIG. 2.—FRONT VIEW OF TILTING FORE-HEARTH.

In addition to the possibility of accurately regulating the flow of metal, any surplus metal may be poured back into the fore-hearth among the hot metal ready for pouring.

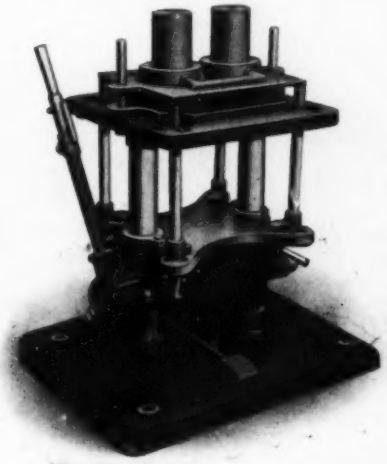
The maker of this apparatus is Carl Rein, of Hannover-List, Germany.

A Hand Ramming Moulding Machine.

In our issue of November, 1907, we published particulars of the "Coventry" moulding machine exhibited that year at the Engineering and Machinery Exhibition, Olympia. The small machine shown herewith, for hand power only, is of similar construction to the lower part of the above-mentioned machine, and while not turning out as much work, is very much quicker than hand moulding. Being able to lift the mould from the pattern perfectly steady, true and parallel, ensures the moulds being perfect, and saves all hand tooling.

These machines are very suitable for deep pistons, air-cooled cylinders and other jobs that can only be rammed by hand, and boys can make on these machines good work with deep intricate patterns that could not be trusted to them to mould in the ordinary way.

The machine in the illustration has a double piston



A HAND-RAMMING MOULDING MACHINE.

pattern, with stripping plate mounted on it. The makers of these machines are the Britannia Foundry Company, Coventry.

The "Adaptable" Moulding Machine.

Herewith depicted is a new adaptable moulding machine which is being manufactured by the Adaptable Moulding Machine Company, Sydney Works, Bishop Street, Birmingham. The chief feature of the machine is that it can be quickly and easily adjusted to work pattern plates varying from 12 to 20 in. in width, the length of the pattern being unrestricted, as the ends of the machine are open. The adjustment is effected by means of a key and screw, the operation of the screw expanding and contracting the movement of the uprights supporting the plate and the moulding box.

The machine has been designed for hand-ramming,

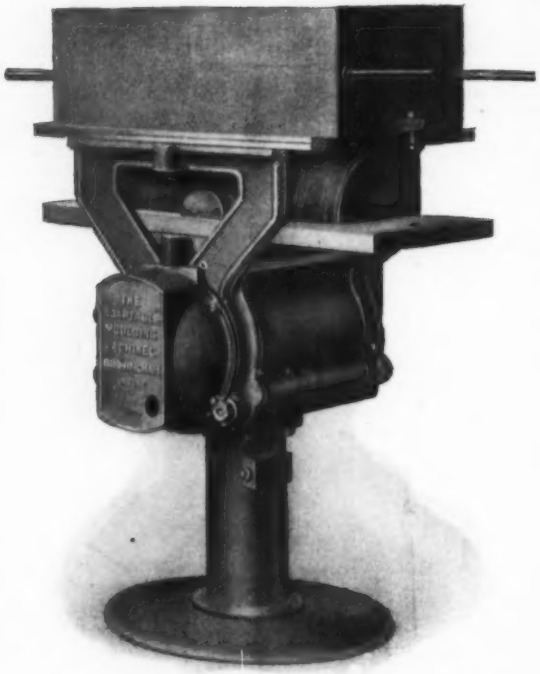


FIG. 1.—"ADAPTABLE" MOULDING MACHINE WITH DEEP PATTERN.

FIG. 2.—"ADAPTABLE" MOULDING MACHINE WITH SHALLOW PATTERN.

which system is claimed to be more effective and to produce cleaner castings than power ramming machines. The pattern plate is 29 in. from the floor, thus giving a minimum lift of sand to and from the floor. This, from the moulder's point of view, is an important consideration. It has a maximum draw of 6 in., and either deep or shallow castings can be successfully obtained.

This machine, also, is portable, and with its circular base, may easily be rolled from one part of the foundry to another. One of the points claimed for it is its accuracy of draw. In drawing the pattern from the mould, the mechanical principle upon which this is done renders it impossible for any inaccuracy to occur.

The machine, being lubricated, works smoothly, and no jerky or uneven movement endangers the correctness of the mould. All the lubricated parts are protected, so that any ingress of sand is prevented. The table part of the machine is faced to allow of correct stooling, the stools being bolted thereto in cases where it is desirable for green sand cores to be rammed up and left in the mould, the provision of this stooling device thus effecting great economies, as

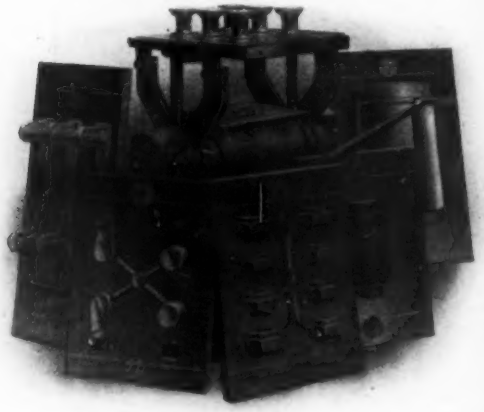


FIG. 3.—"ADAPTABLE" MACHINE, AND SOME PATTERN PLATES WORKED ON SAME.

it dispenses with dry sand cores. The parallel strips on the end frames of the machine are constructed to admit of the adjustment to any thickness of pattern plate, thereby bringing the joint lines of box and plate on one plane. In this way crushing is avoided; consequently clean castings result, and fettling is reduced to a minimum.

From its inception to its completion no care or expense has been spared to produce a moulding machine adapted in every way to meet the requirements of a modern foundry. Patents, it may be stated, have been granted for the machine in all the principal countries of the world.

Fig. 1 shows the "Adaptable" moulding machine with a deep pattern plate, necessitating a six-inch draw, drawn from the mould, with the moulding box ready to be lifted off the machine, while Fig. 2 shows a shallow pattern plate being drawn from mould. As shown in the illustration, the shallow plate is drawn unnecessarily far, as use has not been made of the adjusting bolt seen resting on the base to the left of the column. Fig. 1 shows this bolt correctly in position, thus preventing the same pattern being drawn further than is necessary.

Inventions.

Applications for Patents.

An asterisk indicates that a complete specification accompanies the application. When inventions are communicated the names of the communicators are in brackets.

19,127.*Machine for making moulds for cast chain. A. Schürhoff.

19,129.*Regulating devices for gas furnaces. O. Zahn, 9, Warwick Court, Gray's Inn, London.

19,145. Air bridge for furnaces. C. McIntyre.

19,278. Smelting and casting pure magnesium and magnesium alloys. T. Kern, 30, Hochstrasse, Griesheim, Frankfurt-on-Main.

20,273. Tube-bending machine. T. Bourne, 11, Burlington Chambers, New Street, Birmingham.

20,337.*Process of producing alloys and the separation of metals. P. F. Cowing.

20,382. Moulding machines or presses for making briquettes. H. Berry and H. Berry & Company, Limited.

20,404.*Electrical furnaces. M. Ruthenburg.

15,882 (1909). *Manufacture of Hollow Castings.* Wilhelm Kurze, Wilhelmshütte, Neustadt-on-the-Rübenberge, near Hannover, Prussia, Germany.—This invention relates to the manufacture of hollow castings and more particularly to a method of preparing the metal core or cores prior to their use in the casting operation in such manner that a space or spaces will be provided to allow for shrinkage. The cores are provided with a coating or lining which will melt or be consumed when the hot casting metal is poured in, thus providing a free space or spaces for shrinking of the casting in cooling without binding on the core, which can therefore be left without danger in the casting and be easily removed therefrom when cool. This coating may be effected by spreading over or coating the cores with linseed oil, after which ground silicious earth, which, *per se*, is a known moulding constituent, is applied to the coating of linseed oil for the purpose of "stiffening" this coating which would otherwise be liable to run or flow down the sides of an upright core. The removal of the core may be effected by striking with a hammer or the like against the end of the core or the casting mould. When divided metal cores are used for the manufacture of hollow castings, the inner opposed surfaces of the core sections may be coated instead of the outer surface, the object in either case being that a sufficient space is produced during the casting operation for the free play or shrinkage of the casting. The core itself is unaltered, and can be used for any number of subsequent casting operations, thus differing from those contractible cores made of a mixture of sand and flour which become partially carbonised in the casting operation and are thus rendered useless for further casting operations. In the case of using, in the process of casting hollow bodies, longitudinally divided cores, the sections of the latter are so arranged relatively to each other, that between these sections clearances or shrinkage spaces may be produced. The core can be blackened in the usual manner, or coated with dry black lead, and can be left in the mould until the flasks are emptied.

13,295 (1909). *Electric Furnaces.* Dr. Hans Nathusius, and Westdeutsche Thomasphosphat-Werke, G.m.b.H., Karlsbad 17, Berlin, W., Germany.—This invention relates to a modification of or improvement in the invention described in Specification No. 7,188 of 1908. The furnace for electric smelting and refining of metals, more particularly of steel, described in the prior specification, differs from electric furnaces used for the same purpose, by the fact that both on the surface of the bath and at the bottom of the furnaces are arranged several electrodes connected to successive poles of the generator, in such manner that the electric current is forced to pass from one surface electrode to another surface electrode, from one surface electrode to an opposite bottom electrode, and from one bottom electrode to another bottom electrode. Thus the charge is surrounded by electric currents of suitable heating power. The object of the present invention is to attain further control of the heating by special devices and connections, with the assistance of which the heat can be regulated for those stages of the steel process in which at given places and times the heating must be varied. In this invention the increase of the strength of current in the bath itself or in the hearth sole, in a furnace according to the prior Specification No. 7,188/08 when using three-phase alternating current in accordance with the connections shown in Fig. 1, is obtained by connecting the three inner ends

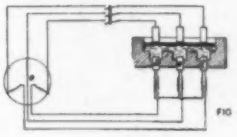


FIG. 1.

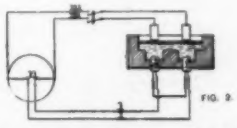


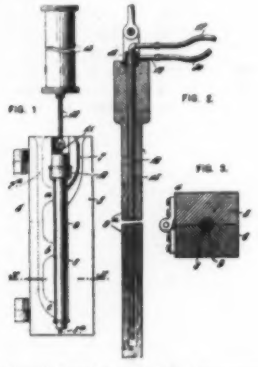
FIG. 2.

Electric Furnace, by Dr. H. Nathusius.

at *o* which usually form the neutral point, respectively to the bottom electrodes *d*, *e*, *f*, whilst the outer ends are connected in the usual manner to the three surface electrodes. By means of this connection the neutral point is transferred into the metal bath itself. The whole strength of current is therefore utilised for heating the metal bath or the hearth sole. In the case of continuous current with three wires according to the connections shown in Fig. 2, the central conductor is divided into two separate conductors *l l* and carried to the bottom electrodes *d f*, and the outer conductors *m m* are carried to the surface electrodes. In the case of a single-phase alternating current for which the connections shown in Fig. 2 is also applicable, two separate connections are made with the bottom electrodes from the neutral point *n* of the machine, so that the neutral point is transferred into the metal bath itself.

15,185 (1909). *Casting Metal Structures in Permanent Moulds Having Permanent Cores.* Edgar Alan Custer, Baltimore Avenue, City of Philadelphia, Philadelphia, Pennsylvania, U.S.A.—This invention relates to the production of homogeneous cast structures either soft or hard, as required, by the use of permanent moulds, and embraces further developments of the art of casting metal structures set forth in the Specifications of Patent No. 16,749/07 and of Application No. 26,559/08. The present invention consists in an improved mode of carrying out the process when casting a structure requiring a core, and is characterised by the fact that the metal is cast around a permanent core and is removed from the influence thereof as well as from the influence of the mould as soon as it is set. If a permanent core is employed and the casting is left in contact with it for any appreciable time after the casting is set the casting will be hard and may even crack. In the aforementioned prior specifications a core is mentioned which comprises a perforated hollow body. Such a body is covered with sand when in use, and can therefore be left in contact with the casting without detriment thereto. The use of a permanent core, however, offers distinct advantages, such for instance as saving of time, since it requires no preparation. Fig. 1, is a view partly in section and partly in elevation of a two-part permanent metal mould, showing internal formations and a permanent metal core suitably connected with a hydraulic or other ram for

lifting the core from the mould after setting of the structure cast, in this instance a pipe, so that the mould can then be opened to allow the structure cast which is homogeneous throughout to cool gradually in the surrounding atmosphere or at a suitable falling temperature, according to conditions and requirements. Fig. 2, is a similar view of a modified form of metal fluid cooled core adapted for use in a permanent mould, where structures are to be cast with greater thickness as to the walls than in the use of a solid metal core of the type of Fig. 1; and Fig. 3, is a transverse sectional view through the permanent metal mould and metal core on the line *x*, *x*, of Fig. 1. Referring to the drawings, 4 is a permanent two-part metal mould 5, 6, or which may be arranged so as to consist of a cope and a drag depending upon, whether occupying a vertical or horizontal position for use. The vertical mould as shown is provided with either a single pour-hole 7, to the right in Fig. 1, or a single pour-hole 7a, to the left in Fig. 1, with a series of branches *a*, *b* and *c*, leading directly to the main cavity 8, of the mould 4, provided with a contracted cylindrical orifice or opening 8a, in the base portion as clearly shown in Fig. 1, for escape of gases, etc. The internal mould cavity 8, is so arranged as to receive a permanent metal cylindriform core 9, which, as shown in Figs. 1 and 2, is provided with an enlargement 10, at one end having an eye 11, to be connected with the piston-rod 12, of a hydraulic ram or other means 13, for liberating the core when required. The two-part mould 4, in Fig. 1, is arranged in a vertical position for the casting operation with the gates or pour-



Method of Casting Metal Structures, by E. A. Custer.

holes 7 and 7a, in the top, but a horizontal mould may be used with equally good results. In such instance, the pour-holes into channel-ways of the interior of the mould 4, may be arranged in substantially the manner shown and described in the aforementioned prior specifications. In Fig. 2, is shown a thick walled hollow permanent metal core 9a, the internal chamber 15 of which is provided with a fluid inlet pipe 16, extending downwardly thereinto. At the upper end the same is connected with a hose or other flexible connection 17, with a fluid supply, not shown. There is also provided a capping 18, having a discharge pipe 19, with a flexible connection 20, to a waste receptacle, not shown. In some instances, where a heavy or thick wall structure is to be cast, it is desirable, as practice has demonstrated, to use a fluid-cooled metal core, in a permanent mould 4, to ensure the proper establishing of the homogeneity throughout of the iron in the resultant product by changed molecular conditions of the metal induced according to the described mode of my said invention and by quickly chilling the molten metal against the core and mould to the point of setting of the metal, whereby, as practice has established, to ensure a general character of structure cast which is throughout homogeneous both as to the interior as well as the exterior.

New Companies.

WULFRUNA ENGINEERING COMPANY, LIMITED.—Capital £5,000 in £1 shares.

CHESNEY ENGINEERING COMPANY, LIMITED.—Capital £5,000 in £1 shares, to carry on the business of engineers, founders, etc.

ROBERTSON ENGINEERING COMPANY, LIMITED.—Capital £4,000 in £1 shares. Registered office: 63, Bath Street, Glasgow.

COVENTRY COSLETTIZING COMPANY, LIMITED.—Capital £1,000 in £1 shares, to carry on the business of rust preventer manufacturers, etc.

W. V. WAITE & COMPANY, LIMITED.—Capital £1,000 in £1 shares, to carry on the business of constructional, electrical, mechanical, and general engineers, etc.

T. GOODBY, LIMITED.—Capital £2,000 in £1 shares, to carry on the business of die sinkers, toolmakers, etc. Registered office: 60, Caroline Street, Birmingham.

WILLIAM LLOYD COOPER, LIMITED.—Capital £1,000 in £1 shares, to take over the business of marine, electric, and general engineers, boiler-makers, etc.

D. H. SYNDICATE, LIMITED.—Capital £500 in £1 shares, to carry on the business of mechanical and electrical engineers, etc. Registered office: 1, Sandys Row, Bishopsgate Street, E.C.

THOMAS E. WHITWORTH, LIMITED.—Capital £5,000 in £1 shares, to take over the ironfoundry business of Thos. E. Whitworth, Bond Street Works, Denton. Registered office: Bond Street, Denton.

JAMES NEIL & SONS, LIMITED.—Capital £11,000 in £1 shares, to acquire the business of furnace engineers, ironfounders, etc., carried on by James Neil at the Grange Foundry, Shettleston, Glasgow.

METRICAL ENGINEERING COMPANY, LIMITED.—Capital £1,000 in £1 shares, to carry on the business of mechanical engineers, contractors, and proprietors of patents heretofore carried on by G. Higginson as the Micrometical Engineering Company.

ENGINE DEVELOPMENT COMPANY, LIMITED.—Capital £21,000 in 20,000 preferred ordinary shares of £1 each and 20,000 deferred ordinary shares of 1s. each, to carry on the business of ironfounders, engineers, etc. Registered office: 7, Princes Street, Westminster, S.W.

YORKSHIRE TESTING WORKS, LIMITED.—Capital £3,000 in £1 shares, to take over the business of metallurgists and analytical chemists carried on at Sheffield as the Yorkshire Mechanical and Testing Laboratory, and to carry on the business of metallurgists, chemists, analysts, assayers, experts in the mechanical testing and inspection of steel, iron, and other metals, etc. Registered office: St. Peter's Close, Sheffield.

MR. JAMES H. MATHIESON, one of the managing directors of Alex. Mathieson & Sons, Limited, Saracen Tool Works, Glasgow, has intimated his intention to retire from the Glasgow Town Council. Another gentleman connected with the iron trade, Mr. Borland, has also intimated his intention of retiring. He founded the City Iron Foundry, Glasgow, in 1872, and has been a member of the Council since 1903.

A NEW journal has been started in this country for the wood-worker, Page's Publishing Company, Limited, having instituted a London edition of the excellent American monthly, "Wood Craft," with offices at 22, Henrietta Street, London, E.C. As instancing the class of subjects treated may be quoted the titles of some articles in the current issue:—"The Sideboard—Its Origin and Development"; "Important Factors in the Operation of Dry Kilns"; "Lay-out for a Small Shop"; "Furniture and Hardwood Polishing"; "Selection and Care of the Surfacer"; "Moulding and Planing Machines for High Speeds"; "Adequate Instruction in the Planing Mill"; and a number of other articles dealing with topics of interest to wood-workers, and illustrating modern wood-working machinery.

Trade Talk.

THE VINCIT COMPANY, LIMITED, makers of abrasive wheels, etc., have removed to 70, Queen Victoria Street, London, E.C.

DAVID SHANKS & COMPANY, LIMITED, art metal-makers, have removed to 115, Wainwright Street, Aston, Birmingham.

MR. R. HODGKINSON no longer represents the Metallic Seamless Tube Company, Limited, of Birmingham, in the Lancashire district.

JOHN SPENCER, LIMITED, Wednesbury, have forwarded to us their catalogue of iron and steel tubes, fittings of all descriptions, tools etc.

THE BRITISH METALS EXTRACTION COMPANY, LIMITED, are contemplating extensive alterations at their Villiers Spelter Works, Llansamlet.

MR. T. INMAN, lately associated with the Spartan Steel Company, Limited, Sheffield, has established himself in business as the Apex Steel Company.

THE centenary of the founding of Newburn Steel Works, Newcastle-on-Tyne, of John Spencer & Sons, Limited, was commemorated last month.

MESSRS. K. C. BAKER, R. C. SLADE, and R. W. CORY, Newport, ironfounders, etc., trading under the style of W. A. Baker & Company, have dissolved partnership.

MESSRS. ALFRED FREDERICK DORE AND WALTER GEORGE BEARDSMORE, brassfounders, 9, Great Brook Street, Birmingham, notify a dissolution of partnership.

MESSRS. GILLESPIE & BEALES, Amberley House, Norfolk Street, Strand, W.C., have been appointed sole wholesale agents by the Berry Construction Company, Limited.

THE buildings, plant, tools, and furnishings of the Dalziel Bridge and Roof Building Company, Limited, have been purchased by P. & W. MacLellan, Limited, Glasgow.

THE Council of the American Iron and Steel Institute has opened offices at Room 606, 30, Church Street, New York, where copies of the leading trade publications will be kept on file.

THE GLOBE GAS ENGINE WORKS, long occupied by the firm of Pollock, White & Waddell, Johnstone, have been taken by a firm in a different branch of engineering, and will soon be occupied by them.

THE WILLINGSWORTH IRON COMPANY, LIMITED, Wednesbury, Staffs., are blowing in a new furnace very shortly for the manufacture of a brand of better-class foundry iron, to be known as "Brunswick."

THE KENYON IRONWORKS COMPANY, LIMITED, has been registered with a capital of £6,000 in £1 shares, to take over the business carried on by W. C. Smith and J. H. Home, in Manchester, as the Kenyon Ironworks Company.

THE first cargo of Bauxite from France will shortly be delivered at the works of the Bauxite Company, Limited, at Hebburn, and operations will then be started for the refining and production of alumina, to be afterwards manufactured into aluminium.

THE ENGINEERING STANDARDS COMMITTEE have just issued the revised edition of the British Standard Specification for Portland Cement (Report No. 12, revised, August, 1910). The principal alterations to the previous edition are dealt with in the preface to the second revision on page 2.

THE shareholders of Sir Theodore Fry & Company, Limited, met at Darlington, last month, for the purpose of formally winding up the company, which is in liquidation. Mr. Peat, liquidator, stated that a first and final dividend of 3s. in the £ would be paid. The report was adopted.

WE understand that Mr. Douglas Upton, who retired from the management of Palmer's Shipbuilding and Iron Company's blast furnaces and rolling mills departments at the end of 1909, which appointment he held for nine years, has started as an iron and steel merchant at 3, Exchange Place, Middlesbrough.

THE extensive works of Babcock & Wilcox, Limited, Renfrew, continue to increase in size. The property of the company extends to an area of 43 acres, and in order to cope with the continued extension of their business they have found it necessary to erect three large additional shops, each 300 ft. long by 60 ft. wide.

MR. T. E. NOAKES, M.I.Mech.E., and Mr. T. W. Dickson, have acquired the goodwill of Thomas Noakes & Sons, Limited, engineers, 4, Osborn Street, Brick Lane, London, E., and the business will in future be carried on as Thomas Noakes & Sons. New offices and a warehouse have been opened at 16, Whitechapel Road, E.

W. & T. AVERY, LIMITED, of London and Birmingham, have just supplied to the Midland Railway Company for their works at Derby, a machine for testing the weight on each wheel of a locomotive, so that any inaccuracy may be at once remedied. It is also fitted with a new patent locking gear which has the advantage of prolonging the life of the machine in a good weighing condition.

A SLUSHING compound for the protection of iron and steel from rust, and the "Carcar" case-hardening compound have been placed on the market by Mr. Arthur Grinyer, of Coventry. The former is prepared to prevent the rusting and tarnishing of the bright iron and steel parts of engines, machinery, tools, etc., in transit, whether packed in cases or unpacked, or for preserving machinery, etc., in good condition when not in use for any length of time.

THE business of Thornton & Crebbin, Limited, ironfounders, Hammerton Street, Bradford, is about to be merged in that of Cole, Marchent & Morley, Limited, engine builders, Prospect Foundry, who have purchased the business of the Hammerton Street firm, and will carry it on as a going concern. The intention is to have all castings made at Thornton & Crebbin's premises, and to limit operations at Prospect Foundry to designing, machining, and finishing.

IT has transpired in Glasgow iron trade circles that the negotiations for the reconstitution of the tube trade combine have proved unavailing. It appears that the negotiations had been proceeding for several months, and at one time the prospects of a successful consummation were distinctly promising, but numerous difficulties in the way eventually proved insurmountable. The British Association, it will be remembered, was dissolved two years ago, following upon the dissolution of the International Association.

AT the Hallside Works of the Steel Company of Scotland, Limited, new and larger workshops have been erected, the old ones having been found unsuitable for the work required of them and entirely inadequate for the company's needs. It has also been necessary to renew the roof over the melting furnaces. At Blochairn Works two of the old melting furnaces have been replaced by one of a capacity of sixty tons. This is the second furnace of this type which has been erected there, and another is in course of construction.

THE UNITED STATES STEEL PRODUCTS EXPORT COMPANY, whose London offices are at 71, King William Street, E.C., have changed their name to the United States Steel Products Company. The change in name is due to the fact that the company handle the entire foreign business of the subsidiary companies of the United States Steel Corporation, comprising all purchases of foreign material for their use as well as all exports of their products, in addition to which the company conduct a construction business in foreign countries.

IN order to cope with trading developments the Cleveland Bridge and Engineering Company, Limited, of Darlington, recently decided to increase the issued amount of their ordinary share capital to £100,000 by the issue of 2,184 ordinary shares of £10 each at par, making £21,840, conditionally on the shareholders taking up three preference for every four ordinary shares subscribed for, which will mean the receipt by the company of £16,380 on the preference capital, and a total receipt of £38,220 additional called up capital.

THE GENERAL FOUNDRY COMPANY, recently incorporated at Bradford, Pa., U.S.A., has equipped a plant with furnaces and machinery for the manufacture of converted steel castings by its own special process, which, it is stated, enables such castings to compete with malleable iron and open-hearth steel. The manufacturer claims that the new product can be tempered and case hardened. During the company's operations some interesting results have been obtained. A complete laboratory is used in connection with the foundry, the new castings being made by the application of scientific methods.

A NEW organisation was launched on September 12 when the initial meeting of the Electro-Metallurgical Society was held in Shefield. The Society is to consist of platers, gilders, those engaged in the refining of metals by electricity, and generally in the application of electricity to metallurgy. The officers were elected as under:—President, Professor Arnold; vice-presidents, Professor McWilliam, Dr. Hutton (of William Hutton & Sons), and Mr. T. Scott Anderson; chairman of committee, Mr. Arthur Parsons; hon. secretaries, Mr. G. Bernard Brook and Mr. Frank Mason; committee, Messrs. W. R. Barclay, A. Barker, W. G. Turner, Charles Puttrell, A. Jefferson, A. Benton, Bryon Carr, and R. W. Girdwood.

THE first lecture of the inaugural session of the Scottish Branch of the British Foundrymen's Association was delivered on September 10 at the Technical College, Glasgow, by Mr. George Hailstone, of Birmingham, who dealt with "The Work of an Iron Foundry Laboratory." He explained that in an up-to-date works the mere tabulating of analyses was only a minor part of the work of a foundry chemist, who should be sufficient of a metallurgist to conduct microscopical and physical tests of the metals used and produced. The responsibility of securing the required results by scientific mixing would fall on his shoulders, and a systematic method of investigation for rectifying defects should be established. By means of graphs the lecturer showed how important it was to keep a record of deliveries of what purported to be a uniform quality of pig-iron, but which often varied in composition between rather wide limits.

AT the Barrow Works of Vickers, Sons & Maxim, Limited, a new alloy, named "Duralumin," has been produced recently, which is expected to play a most important part in the future in the construction of bodies where extreme lightness and strength is the very first consideration. Mr. H. B. Weeks, head chemist at the Naval Construction Works at Barrow, in the course of investigations has found an alloy that Messrs. Vickers, Sons & Maxim believe to be so superior to everything of its kind hitherto manufactured that the directors have decided to manufacture it on a large scale. It is an alloy that, whilst being but slightly heavier than pure aluminium, is as strong as steel. It can be rolled, drawn, stamped, extruded, or forged at suitable temperatures, and will give, according to the alloy used, and the manner in which it is treated, from 25 tons per square inch with 20 per cent. elongation, and up to 35 tons per square inch with 10 per cent. elongation. It is also much less easily corrodible under all the usual corrosive tests than other high aluminium alloys. For many reasons the company would have liked to have manufactured it at Barrow, but on account of the greater facilities existing, and especially on account of the advantages it offered as a distributing centre, Birmingham has been selected, and buildings are now in course of construction—in fact, are nearly completed—that are intended solely for its manufacture, and it is hoped that the company will be able to put it on the market some time during this month. In many instances it will be possible by its use to reduce weight by two-thirds, without sacrificing strength or durability. Mr. Joseph Wilks, of the Barrow Yard, has been selected to take charge of the works at Birmingham.

REGULATIONS made by the Board of Trade, under Section 12 of the Trade Boards Act, 1909, as to the constitution of district trade committees, were issued recently as a Parliamentary paper. They provide that a district trade committee of a trade board shall consist of members of the trade board, representing employers and workers in equal proportions; such one or more appointed members of trade boards as may be directed to act on the committee by the Board of Trade; representatives of local employers and workers in equal proportions. When a trade board desire to establish a district trade committee they shall furnish to the Board of Trade a statement showing the areas for which the district trade committee is to be established, and the Board of Trade shall, after giving an opportunity to the trade board to be heard, determine the number of representative members of the trade board to be nominated as members of the district trade committee by the members of the trade board representing employers and workers respectively, and the number and method of selection of members of the district trade board, due regard being paid to the proper representation of home workers of the trade. Members of the trade board representing employers or workers shall, say the regulations, be chosen to act upon a district trade committee by the representatives of employers or workers as the case may be, on the trade board. A casual vacancy shall be filled in the same manner. The Board of Trade may in certain cases nominate additional representative members, and such representative members may be nominated either for the whole term of office or for any part thereof, the number of such acting at any one time not exceeding one-third of the total number of representatives constituted in the first instance.

Deaths.

MR. P. HOOLE, engineer, of South Reddish, Stockport, died recently, aged 68 years.

MR. U. BINNS, of Messrs. Binns Bros., engineers, Halifax, died recently, aged 76 years.

THE death took place recently of Mr. J. Griffiths, of Messrs. Griffiths Bros., tool-makers, Caergwrle.

THE death is announced of Mr. S. Cronkshaw, of Messrs. James Cronkshaw & Sons, engineers, Waterside, Haslingden.

MR. C. D. POCHIN, of Messrs. E. A. Pochin & Brother, engineers, Trafford Park, Manchester, died on August 22 last, at the age of 32 years.

MR. W. R. D. MOON, of W. R. Moon & Company, Limited, engineers' stores merchants, Commercial Street, Middlesbrough, died recently, aged 55 years.

THE death occurred at Weissenburg, Switzerland, on August 23, of Sir George Robson Palmer, Bart., eldest son of the late Sir Charles Mark Palmer, M.P., of Jarrow.

THE death occurred recently, at his residence, The Shrubbery, Stourbridge, of Mr. J. Holt, head of Messrs. Holt & Willetts, engineers, ironfounders, etc., Cradley Heath, aged 66 years.

MR. WILLIAM FINLAY, principal of the firm of William Finlay & Company, electrical and mechanical engineers, brassfounders, etc., 27, Frederick Street, Edinburgh, died on September 8, after one day's illness. In June last he completed his year of office as President of the Electrical Contractors' Association. He was 38 years of age.

THE death is announced of Mr. Richard Groves Holland, a former Master of the Cutlers' Company. His father, Mr. Richard Holland, was a steel and file manufacturer, and to this trade the son was apprenticed. Forty-eight years ago Mr. R. G. Holland commenced business on his own account as a steel converter and Swedish iron merchant. He was one of the first to assist in breaking down the monopoly enjoyed by London and Hull merchants of that day in supplying Swedish iron to the Sheffield trades.

COMPLETE

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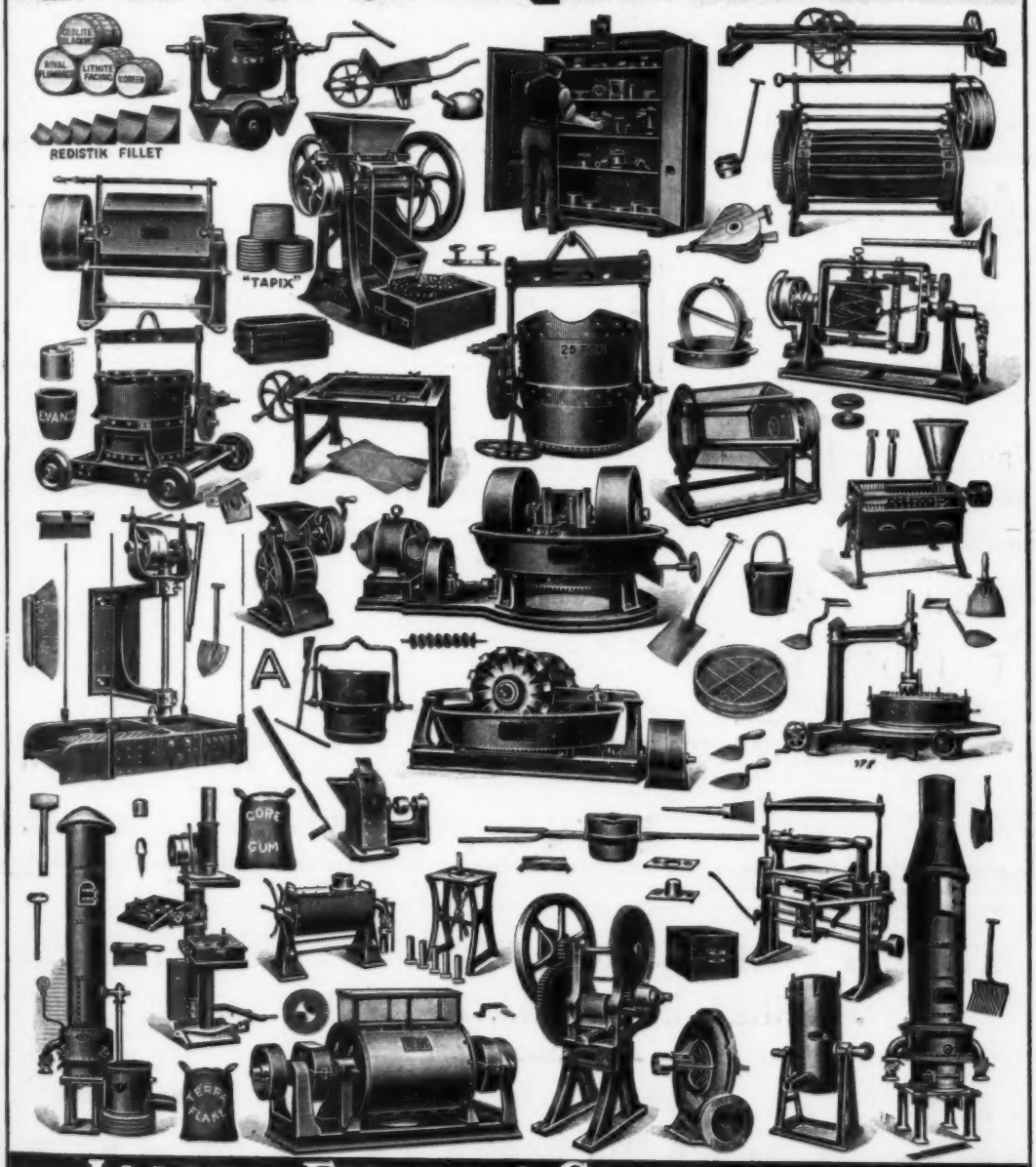
Telephone: "N° 2297 CENTRAL" MANCHESTER.



JAMES EVANS & Co. BRITANNIA WORKS, BLACKFRIARS, MANCHESTER.

Personal.

Mr. A. C. Ross, connected with the engineering staff of R. & W. Hawthorn, Leslie & Company, Limited, has been elected a director of the company, in place of Sir Arthur Bigge, resigned.

Mr. George Senior was on August 23 elected as Master Cutler of the Cutlers' Company of Sheffield for the ensuing year. Mr. Arthur Balfour, of Seebohm and Dieckstahl, Limited, was elected Senior Warden

Mr. E. A. Nash, A.I.C.S., A.I.E.E., has been appointed secretary and business manager of the Electrical Standardising, Testing, and Training Institution in succession to Mr. H. Foulds, resigned.

Mr. J. E. H. Allbut, secretary of the British Foundrymen's Association, has accepted a position on the staff of the British Westinghouse Electric and Manufacturing Company, Limited, Trafford Park, Manchester.

Mr. T. Peers, an official of Messrs. Henry Bessemer & Company, Limited, Bolton Works, has now severed his connection with that firm, having gone into another profession, and has been presented by the workmen with a marble timepiece and bronzes, also a smoker's companion.

At a special congregation at the Sheffield University, the Chancellor (the Duke of Norfolk) conferred honorary degrees upon a number of the distinguished visitors to the British Association meetings and others. The recipients of degrees included:—Doctor of Laws: The Lord Mayor of Sheffield (Lord Fitzwilliam). Doctor of Science: Mr. W. Bateson, the Rev. T. G. Bonney, Sir William Crookes, Mr. Francis Darwin, Professor T. W. Rhys Davids, Sir Archibald Geikie, Professor E. W. Hobson, Sir Oliver Lodge, Sir Norman Lockyer, Dr. H. A. Miers, Sir William Ramsay, Professor C. S. Sherrington, Sir J. J. Thomson. Doctor of Engineering: Sir Joseph Jonas and Sir W. H. White. Doctor of Metallurgy: Mr. J. E. Stead.

ANALYSIS
in the
Foundry.

SPECIAL OFFER

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Readers desiring analyses of:—
PIG-IRONS, CASTINGS, ALLOYS and all METALLURGICAL PRODUCTS
Should address their samples to
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Arrangements have been made for carrying out this work at the following low charges:—

PIG-IRON	Determination of	1 Constituent ..	£0 6 6
"	"	5 Constituents ..	1 5 0
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" " ..	"	Complete Analysis ..	1 15 0
COKE	.. .. ..	per Constituent ..	0 6 6
CUPOLA SLAG ..	.. .. ..	" " ..	0 6 6
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WE ARE
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ENGINEERING AND MACHINERY EXHIBITION, MANCHESTER,
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STRONG, CLOSE-GRAINED

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"TITANIUM THERMIT"

TINS READY FOR USE. ALL SIZES from 2 cwt. to 20 tons.

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ELDERS FOUNDRY COKE

AS SUPPLIED TO THE BRITISH ADMIRALTY DOCKYARDS.

The following, selected from numerous letters, are eminent testimony as to the quality of our celebrated "A.A.A." Coppee Foundry Coke, carefully selected, and despatched in sheeted wagons.

From PECKETT & SONS, Bristol.

Bristol, October 25th, 1904.

We have been using your Selected Foundry Coke for some considerable time.
We have pleasure in stating that we are very pleased with it, as we find we get sounder and cleaner castings, more free from blowholes and other defects, than we formerly did.

From BOW, McLACHLAN & CO., LTD. (Paisley Foundry), Paisley, Glasgow.

Paisley, 12th March, 1909.

We have yours of 4th inst., and in reply have pleasure in stating that we have been using your Foundry Coke for several years for special purposes with highly satisfactory results.

Elders Navigation Collieries, Ltd., Cardiff.

Query.

Oxide of Iron in Slag.

May I ask if any readers have any particulars of what a reasonable percentage of oxide of iron contained in cupola slag should be, according to practice in various iron foundries; also the air pressure at which the lowest percentage is obtained?

Reply.

The Mixing of Metals.

If "Seeker" will turn to page 71 of "General Foundry Practice," by Roxburgh, he will probably be much assisted by reading "Metal Mixing" and other chapters which all more or less touch on the work in question. Also, in the third division of the same book, which deals with the finer metals, brass mixtures, etc., and other alloys are dealt with, and this may in some measure assist him out of his difficulties.

"SUBSCRIBER."

SCRAP.

The quotations for scrap, subject to market fluctuations, are as follows:—Heavy wrought (mixed), £2 10s. 0d.; light wrought, £1 7s. 6d.; heavy cast, £2 8s. 0d.; all per ton f.o.b., London. Copper (clean), £52 10s. 0d.; brass (clean), £38 10s. 0d.; lead (usual draft), £11 15s. 0d.; tea lead, £10 15s. 0d.; zinc, £18 15s. 0d.; all per ton delivered merchant's yard.

PRICES OF METALS.

The following table shows the approximate latest prices and position of stocks of metals during the past two years:—

METALS.	End Sept., 1910.	End Sept., 1909.
Iron—Scotch pig warrants ton	54/10½	*58/4½
—Middlesbro' warrants .. ton	48/10½	52/7½
—W.C. M/nos Bessemer ... ton	67/6	62/0
—Stock, Scotch ... ..tons	1,000	1,000
Copper—Chill bars, GMB ton	£54 15 0	£59 7/6
—Stock, Europe and afloat tons	—	93,851
Tin—English ingots ... ton	£157 10 0	£134 10 0
—Straits ... ... ton	£157 15 0	£133 17 6
—Stock, London, Holland, U.S.A., and afloat ...tons	—	22,025
Lead—English pig ... ton	£13 0 0	£13 10 0
Spelter—Ord. Silesian ... ton	£23 12 6	£23 5 0
Quicksilver (75lb)... bottle	£8 12 6	£8 7 6
Antimony—Regulus ... ton	£28 0 0-£30 0 0	£30 0 0

* Settlement price.

CASTINGS.

In the Cleveland district the following are the nominal rates current for castings:—

	£ s. d.		£ s. d.
Columns (plain)	5 10 0	to	6 15 0
Pipes, 1½ to 2½ in.	4 17 6	to	5 2 6
,, 3 to 4 in.	4 10 0	to	5 0 0
,, 5 to 8 in.	4 7 6	to	4 10 0
,, 10 to 16 in.	4 7 6	to	4 10 0
,, 18 to 24 in.	4 7 6	to	4 10 0
Chairs	3 10 0	to	3 12 6
Floor plates (open sand)	3 0 0	to	3 5 0

GANISTER, CUPOLA BLOCKS, FIRE BRICKS,
FIRE CLAY.
Silica Bricks, Tuyeres, Stoppers, Nozzles, &c.
STEEL MOULDERS' COMPOSITION, SILICA CEMENT.
J. GRAYSON LOWOOD & Co., Ltd.,
DEEPCAR, nr. SHEFFIELD.
Telegrams: "LOWOOD, DEEPCAR."

Ironfounders' Charcoal Blacking, Mineral Blacking, Coal & Coke Dust Manufacturer,
&c.
JAMES SYKES, HURST CHARCOAL MILL, Near ASHTON-UNDER-LYNE.
ESTABLISHED 1854.

Established 1863.

JAS. DURRANS & SONS,

PHŒNIX WORKS, PENISTONE, Near Sheffield.

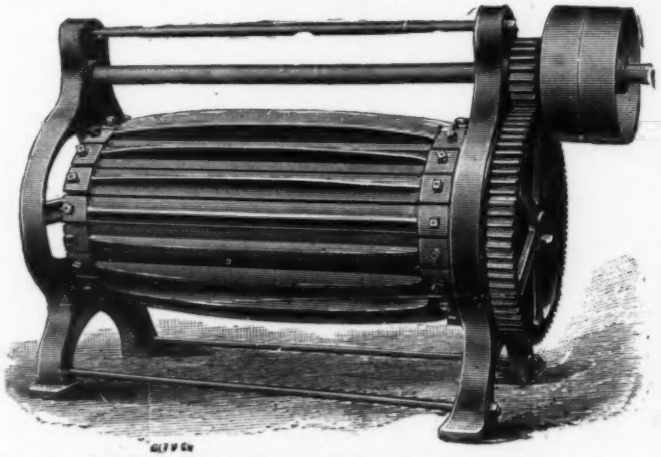
Manufacturers of all

FOUNDRY EQUIPMENTS,

COMPOSITION BLACK LEAD, PLUMBAGO, CORE GUM, WHITE DUST & COAL DUST.

Ladles, Cupolas, Fire Bricks, Gannister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, Etc.

IMPROVED FOUNDRY RATTLER or FETTLING DRUM.



These Machines are invaluable for a Foundry, doing a larger amount of work of a superior quality, in a much shorter time than can be done by hand, without skilled labour.

"Dear Sirs,—We have been using your best Blacking for a large number of years, and always use it on our large Ingot Moulds, which, as you know, we have made up to 85 tons in weight.

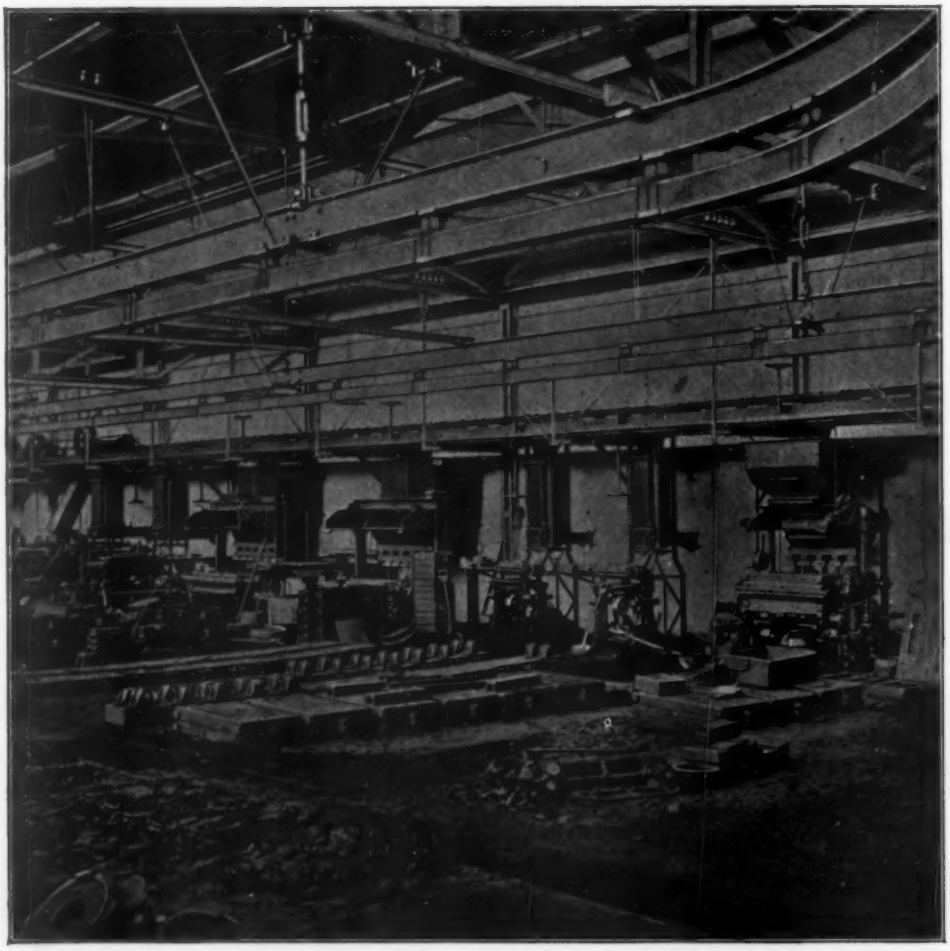
Yours faithfully, THE BRIGHTSIDE FOUNDRY & ENGINEERING CO., LD."

THAT'S GOOD ! !

We have heard this expression many times when showing Foundrymen this photo of one of the up-to-date foundries equipped by us. The sand is carried to the Moulding Machines by an overhead conveyor and is delivered into the moulding boxes by trays ; the operator shovels in the facing sand, that's all. The metal is brought to the men by the overhead runway shown, and the boxes are shaken out over the grating in the middle, under which is a conveyor which carries the sand back to the Sand Preparing Machines.

Result—Costs reduced to half and first-class Castings.

"LEWCO FOUNDRY" PLANT IS STANDARD.



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THE BUYER'S GUIDE

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Jackman, J. W., & Co., Ltd.
Olsen, Wm.

Blacklead.
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Evans, J., & Co.
Hall, Charles, & Co.
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Olsen, Wm.
Walker, I. & I.
Wilkinson & Co., Thos., Ltd.

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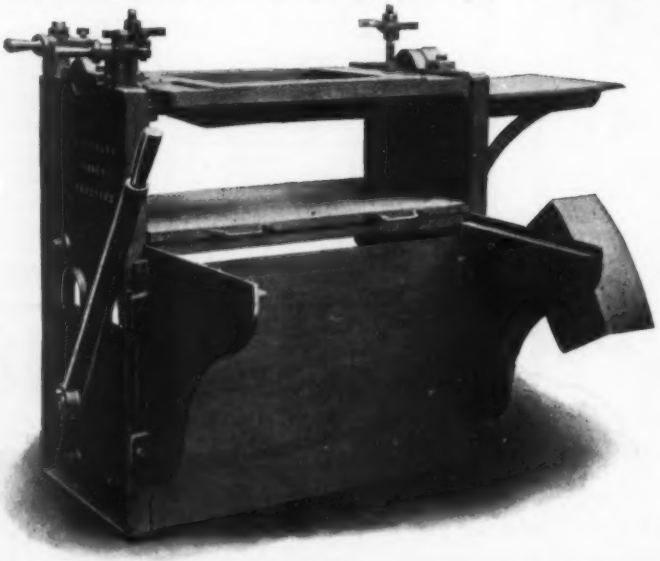

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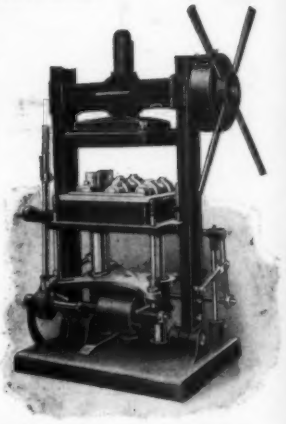

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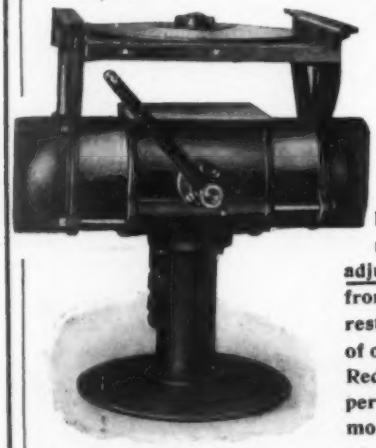

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It is six machines of its type in one, and the only truly adaptable machine built or protected by patents. ∴ Is quickly and easily adjusted, by means of a handle key, to accommodate any pattern plate of from twelve to twenty inches in width, the length of pattern being unrestricted. ∴ Will quickly draw patterns six inches deep to an accuracy of one-hundreth part of an inch. ∴ Can be operated by unskilled labour. Reduces cost of castings, increases capacity of foundry. ∴ Ensures perfect uniformity of castings; works deep and shallow patterns in one mould with equal success. ∴ Minimises floor space, is portable, and ∴ ∴ ∴ ∴ ∴ of convenient size. ∴ ∴ ∴ ∴ ∴

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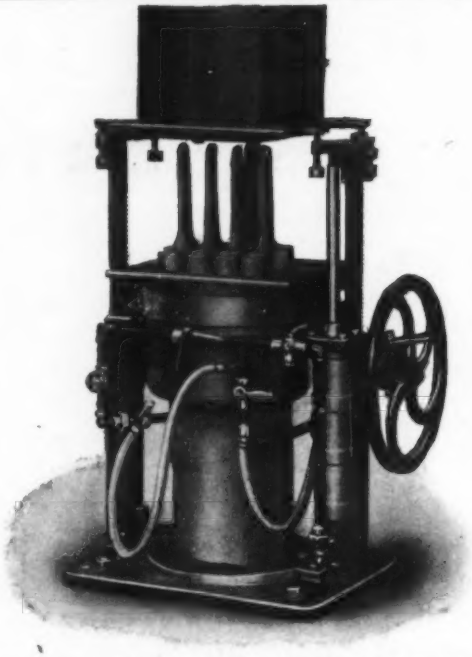

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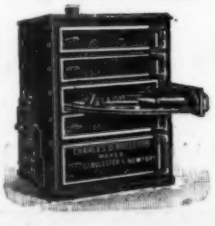

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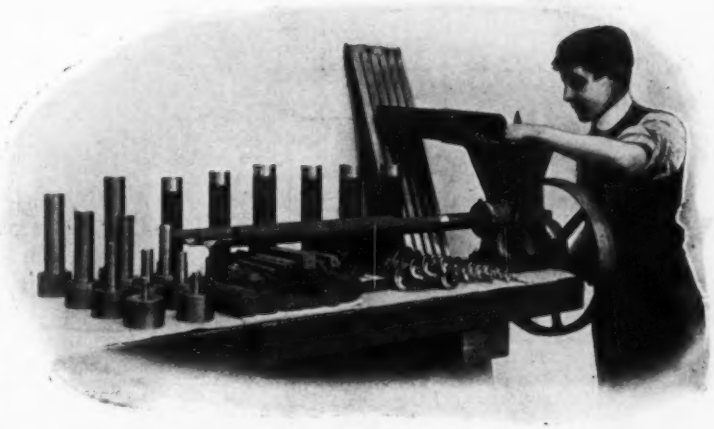

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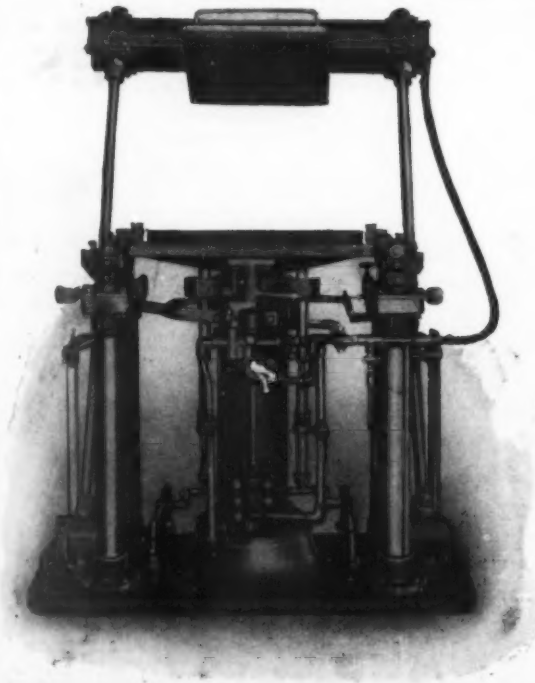

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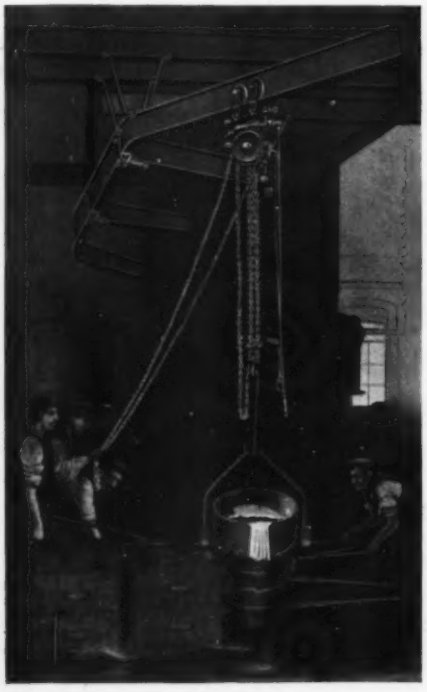

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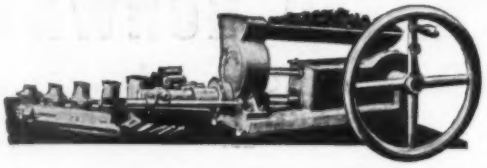

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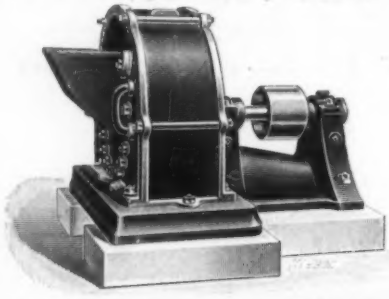

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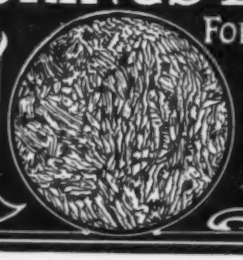

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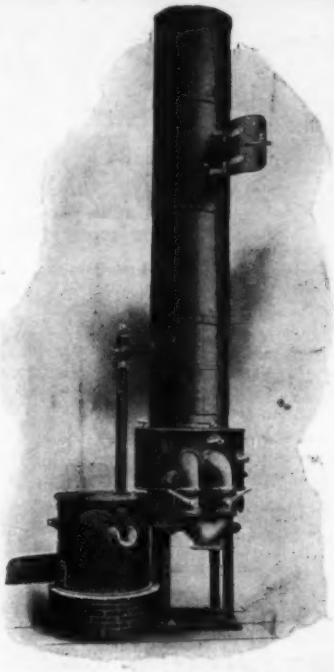

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